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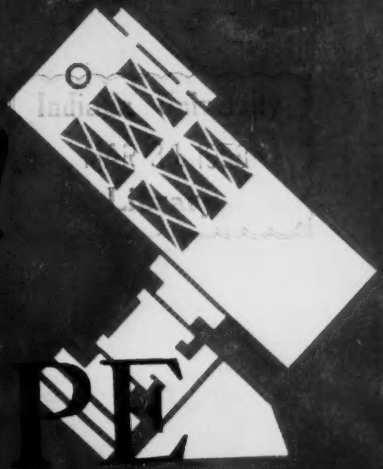

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Vol. XVII, No. 6

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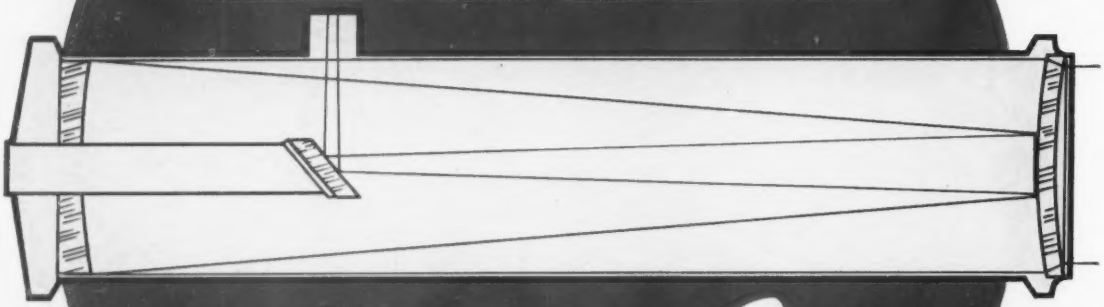

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COVER: One of the most remarkable colored displays of northern lights in recent years was an all-night spectacle over the United States on February 10-11. Here a dull-red patch with rays is reflected from the ice covering Mystic Lake at Arlington, Massachusetts. Paul Donaldson took this picture at 5:20 a.m. Eastern standard time, with an f/3.5 Rolleiflex camera, a 45-second exposure on Tri-X film, which he developed in DK-50 for 15 minutes. (See page 280.)

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New Comet Burnham

THE FIRST comet discovery of 1958 was made on the evening of February 21st by Robert Burnham, Jr., a 27-year-old amateur of Prescott, Arizona, who less than four months before had been a codiscoverer of Comet 1957f (Latyshev-Wild-Burnham).

Recently Mr. Burnham has been working at Lowell Observatory, Flagstaff, on its proper-motion survey program. That Friday evening he drove 90 miles home from work, ate dinner, and went outdoors to try his new 8-inch reflector. Within 15 minutes he spotted a 9th-magnitude cometary object near Betelgeuse in the constellation of Orion. He then drove back to Lowell Observatory to report his find to acting director E. C. Slipher. A telephone call to the U. S. Naval Observatory's Flagstaff station resulted in a prompt photographic confirmation by Dr. Elizabeth Roemer with the 40-inch reflector there.

Both observers agreed that Comet 1958a was a diffuse object with a central condensation, of about visual magnitude 9, but on the 40-inch plates it appeared magnitude 15. According to an observation on February 24th, by J. L. Gossner at the U. S. Naval Observatory, Washington, D. C., the brightness was 10th magnitude.

After news of Comet Burnham reached Europe, images of this object were recognized on two prediscovery photographs taken on February 10th and 16th at Sonneberg Observatory, East Germany. These plates show the comet's total magnitude as about 11, according to *Circular* 1642 of the International Astronomical Union.

Preliminary orbits for the comet have been computed by Marsden at Oxford, England, and by Dr. Roemer. She used her positional measurements of February 22, 25, and 28, 1958, and for calculating purposes assumed the path of the comet around the sun to be a parabola. She finds that the comet will be nearest the sun on April 16th, while the Marsden date is the 24th. Its least distance from the sun will be between $1\frac{1}{3}$ and $1\frac{1}{2}$ astronomical units, placing it a little inside the orbit of Mars. The path of the comet is inclined only about 16 degrees to the plane of the ecliptic.

During April, the comet will be in the evening sky, moving from Gemini into Cancer. Its brightness should change little in the course of the month, for as the comet nears the sun it will gradually recede from the earth. By the end of the month, its distance from us will be about 80 million miles.

The following ephemeris by Dr. Roemer is taken from Harvard *Announce-*

(Continued on page 283)

Very bright auroral curtains fill the sky during a display of northern lights in Alaska in January, 1958. The author used a Leica camera, f/1.5, the exposure being a few seconds on Tri-X film. For a brief interval, this extremely active display became a type-B (low red) aurora.

Origin of the Aurora — I

JOSEPH W. CHAMBERLAIN

Yerkes Observatory
University of Chicago

SPECTACULAR and multicolored displays of the aurora borealis or northern lights have bewildered curious minds for many ages. Superstition, mythology, and picturesque explanations involving reflections of sunlight from polar ice began to give way to serious scientific speculation early in the 18th century. Hypotheses for the origin of the aurora were advanced by the astronomer Halley, the chemist Dalton, and the physicist Faraday, who are remembered for their contributions in other fields. Lomonosov in Russia, Canton in Great Britain, and Franklin in America developed ideas on the aurora in connection with their studies of lightning discharges.

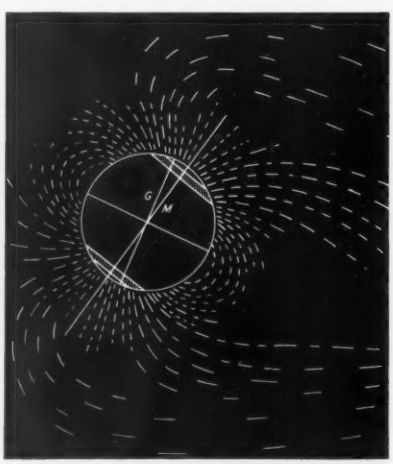
While this early work recognized the electrical character of the aurora, it was doomed to failure because too little was known about the nature of the aurora itself and theoretical physics.

Today we have many more facts about the aurora, and we have electromagnetic theory and quantum mechanics, for example, to guide our interpretations. Yet we must admit that we do not know what causes the aurora. The 20th century has seen a number of hypotheses on the origin and nature of the aurora, but we are still faced with essentially the same sort of difficulties as were Franklin and the other early investigators. First, there are many things about the aurora itself that we do not know and that we need to know in order to construct a satisfactory theory. Added to this is our ignorance of several features of the behavior of matter in the large.

But before we discuss the various auroral theories, let us review the pertinent facts. Just what is the nature of the phenomenon that we are trying to explain? What are the data that we can or would like to put into an auroral theory?

Auroral zone. Aurorae occur most frequently in two belts (one in the Northern Hemisphere, the other in the Southern) that lie about 20 to 25 degrees from the magnetic poles of the earth. If we imagine the earth's magnetic field as being produced by a large bar magnet that is placed at the center of the earth, the magnetic poles are the points at which the axis of this magnet would penetrate the earth's surface. In the Northern Hemisphere this pole is near Thule in northwest Greenland. The auroral zone runs from north-central Alaska through Labrador and arctic Norway.

Aurorae are seen less frequently outside the auroral zone, but they are often observed in the northern United States, and on rare instances have been seen as far south as Mexico City. The great aurora initiating the International Geophysical Year on July 1, 1957, was observed in Cuba. Near the center of the auroral zone (close to the geomagnetic pole) displays are also less frequent, although aurorae can be seen upon occasion at the poles. The auroral zone is not stationary, but shifts toward the equator during the time of sunspot maximum,



The earth's magnetic field is indicated by short dashes, with G and M the earth's rotational and magnetic axes, respectively. The long dashed lines, showing schematically the paths of charged particles from the sun, are curved by the terrestrial field, entering the atmosphere most easily at the north and south auroral zones, which are shaded in the diagram.

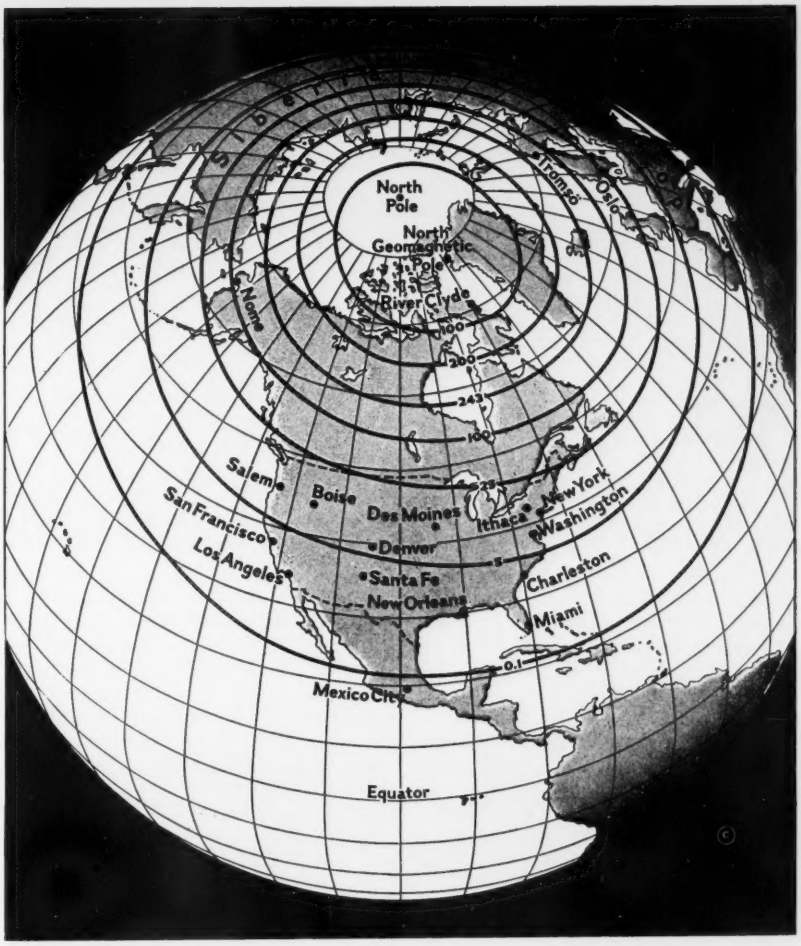
and toward the poles near sunspot minimum. The shift is rather spectacular to an observer living near the average auroral zone. C. T. Elvey, at the Geophysical Institute near Fairbanks, Alaska, noted that aurorae during sunspot minimum occurred primarily to his north; but at the present time of sunspot maximum, northern lights at Fairbanks are seen predominantly south of the zenith. At lower latitudes this shift in the zone of maximum frequency provides observers with many auroral displays. It is still not known whether more aurorae occur on a *world-wide* basis during the time of sunspot maximum or not. The greater number of displays seen in the United States at the present time may be entirely due to this southward shift.

The occurrence of aurorae also goes through a pronounced yearly variation with two maxima, in March and September. This does not mean that an aurora cannot occur in midwinter or midsummer, but merely that the most likely time for seeing one will be in September-October or in March-April (see page 215, March *Sky and Telescope*).

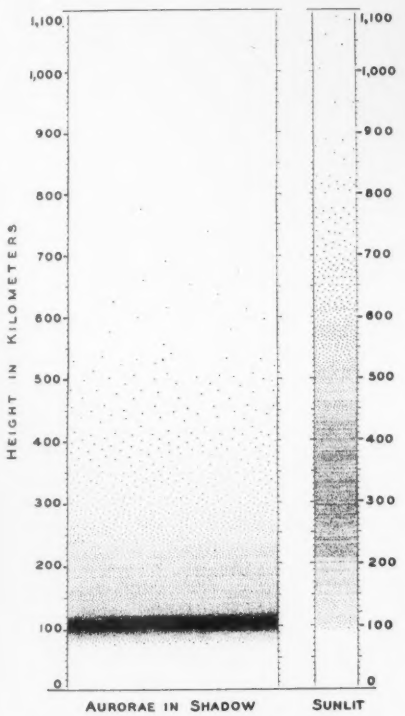
The heights and forms of the aurora. Our present knowledge of the height of the aurora in the atmosphere is largely due to the extensive photographic investigations of the late Norwegian mathematician, Carl Störmer. The lower edge of an ordinary green display is normally in the region around 70 miles above the surface of the earth. Occasionally an aurora will be slightly lower than this. In particular, the so-called type-B red aurora, which appears as a red lower border on an otherwise green display, will be located a few miles lower. Type B is always very active and short-lived, with the red color lasting a few minutes at most. Type-A red aurorae are more quiescent and are red at the upper parts of a display. These reddish rays (and sometimes arcs) may lie several hundred miles above the earth.

The quiet, homogeneous-arc form of the aurora is usually some tens of miles thick in the vertical direction, gradually fading out toward higher altitudes, and is probably less than one mile thick in the north-south direction. It may stretch from west to east several hundred miles around the earth, lying parallel to a circle of geomagnetic latitude. The long thin rays that constitute draperies, coronas, and other active forms of the aurora may be several hundred miles in length. The individual rays are generally short-lived, but they will disappear and reappear in the same position within a few seconds. Occasionally bright red patches will be seen to last for a few minutes. Perhaps the most spectacular type of display is what Störmer has called the flaming aurora. Here wavelike patches of light will start low in the north and rise high into the sky, to disappear within a second or so. An entire train of these waves may persist for several minutes.

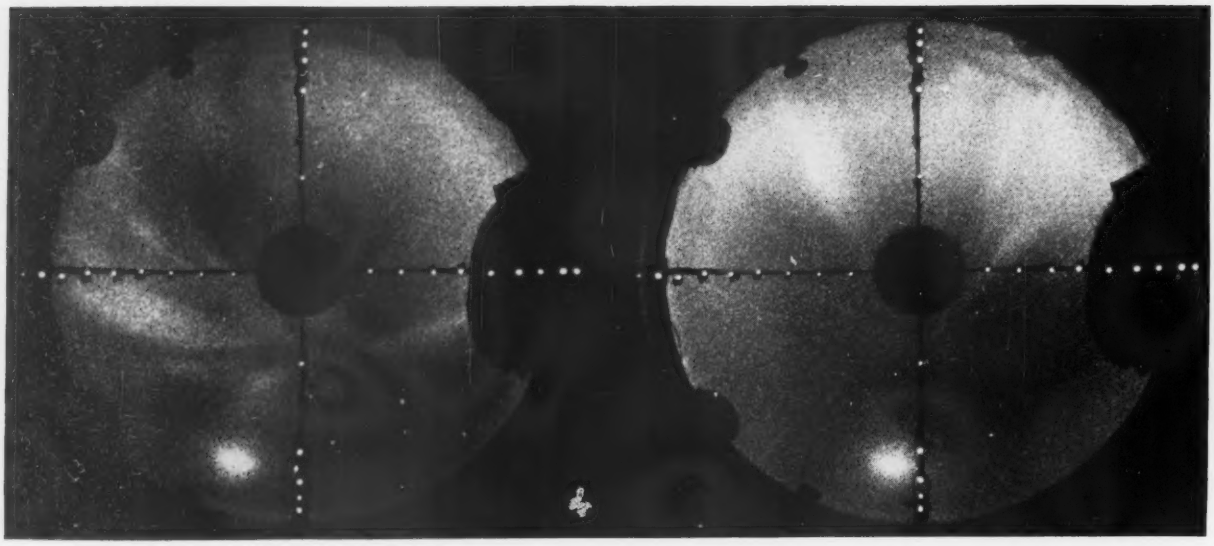
Often an auroral display will start with an arc stretching across the north, appearing very uniform and quiet. Later this arc may break into rayed structure as the aurora moves southward. In full development, the rays will grow into high and active forms, including the magnificent draperies. The display may fade out within a few minutes or it may persist through the night. Sometimes it will fade



This map shows the estimated number of days per year of visible aurora in the Northern Hemisphere, from E. H. Vestine's analysis of data from 1700 to 1942. The contour lines of equal frequency are approximately centered on the magnetic pole in Greenland, where, however, displays are less numerous than in northern Canada, Alaska, and Iceland. The line of maximum auroral frequency corresponds to the average position of the auroral zone. Drawn by Harry S. Oliver.



Carl Stormer has plotted dots representing thousands of height measurements of aurorae in southern Norway. At the left, nighttime displays are concentrated at altitudes near 100 kilometers, but aurorae in the sunlit upper atmosphere, while the observer is in shadow, tend to be much higher. From "The Aurorae," by L. Harang, 1951, Chapman and Hall, Ltd., London.



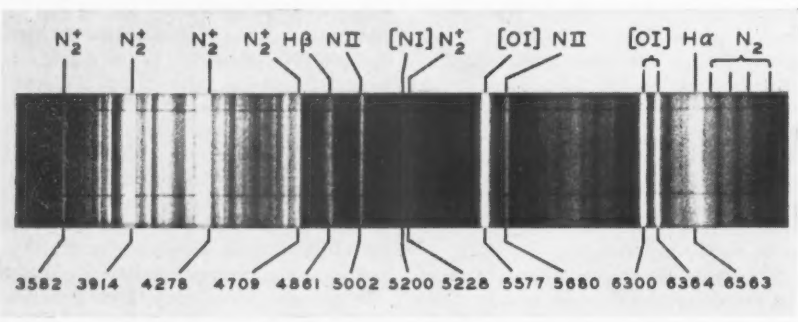
At Yerkes Observatory, Williams Bay, Wisconsin, the all-sky auroral patrol camera recorded the colored display of February 10-11, 1958. The left-hand view, at 5:07 a.m. Central standard time, shows rays converging on the magnetic zenith (south of the astronomical zenith); the other picture was taken at 5:49 a.m., when the display was bright in the north. The exposures were 20 seconds, on Tri-X film; white spots mark 10-degree altitude intervals. The moon is the overexposed patch east of the meridian, and the Yerkes 40-inch refractor dome is at the right.

out, only to be followed by a similar sequence of events beginning with the homogeneous arc.

Aurorae and the sun. While there seems to be some correlation between the aurora and activity on the surface of the sun, the relation is not too impressive. One cannot observe the sun and confidently predict that an aurora will occur. However, on a statistical basis aurorae do seem to be related to solar activity, and if an auroral display does follow a solar flare this is likely to happen in about a day. This relationship has led to speculation that the travel time for a stream of gas from the sun to the earth is approximately one day, implying an average speed of about 1,000 miles per second. But protons or electrons traveling at that speed would not be able to penetrate the atmosphere down to a height of 70 miles, because of the slowing down of the particles as they collide with air molecules at greater heights. To reach the lower auroral levels, it seems that protons would need about five times that initial speed and electrons considerably more.

At the earth, the aurora seems to be associated with a number of other geophysical events, the most outstanding being small disturbances in the earth's magnetic field. These are called *magnetic storms* and are due to electric currents either in the upper atmosphere or in the interplanetary medium near the earth.

Ordinarily, magnetic storms disturb the earth's field by less than one per cent. But the storm that accompanied the great aurora on February 10-11 of this year altered the field at Yerkes Observatory by as much as three per cent at times during the night. A theory of the aurora should also give a satisfactory explanation of the main features of magnetic storms, and vice versa.



An IGY patrol spectrogram of a green aurora. The very intense green line at 5577 angstroms is due to oxygen atoms, as are the strong lines at 6300 and 6364 in the red. Other features come from neutral and ionized molecules of nitrogen, atomic oxygen and hydrogen. In aurorae of other colors, the relative intensities of these lines may be different. Brackets indicate "forbidden" radiations, appearing only at very low gas densities.

Auroral spectrum. Most of the light seen during a display is produced by oxygen and nitrogen atoms and molecules belonging to the earth's atmosphere. The normal color of aurorae is a yellowish green, which is produced by atomic oxygen excited at low pressures. Similarly, the high red aurorae (type A) are produced by atomic oxygen emitting under conditions of still lower pressure. The low red aurorae (type B) receive their color from ionized molecular oxygen (O_2^+) and molecular nitrogen (N_2). Occasionally very high aurorae may be seen in the sunlit portion of the upper atmosphere during astronomical twilight. These will have a bluish tinge, produced by molecular nitrogen with one electron removed (N_2^+).

The great February aurora was of type A; these red displays are relatively more common during a sunspot maximum. Although it is not uncommon for a bright aurora to exhibit occasional red patches and rays, displays will in few cases show so much red, and for such long periods, as did this aurora. When one of these red aurorae is seen near the horizon it may resemble a distant fire. Seneca described such an event in the first century, when the Roman legions rushed to the rescue of a city thought to be aflame.

The yellow appearance of some aurorae is not caused by yellow emissions in the auroral spectrum, however. Rather, it is produced by comparable amounts of red and green light, which are blended by the observer's eye, in this way causing a yellow sensation.

It is important in studying the cause of the aurora to have accurate measurements of its brightness versus height in the atmosphere. These *luminosity curves*

can give valuable information on the nature of incoming particles and on the speeds of atmospheric electrons producing auroral luminosity.

Besides the oxygen and nitrogen emissions, we occasionally find radiation in the red and blue that is produced by hydrogen gas. From measurements of the precise wave lengths in the spectrum (the exact colors) of these radiations, it has been determined that the hydrogen producing this light is entering the atmosphere from extraterrestrial space. When an atom emits light while it is moving at high speed, the color of the radiation is slightly altered; this phenomenon is called the Doppler shift.

For example, if hydrogen gas emits light while it is moving away from the observer, all of the light is slightly redder than light produced by hydrogen in the laboratory. On the other hand, if the atoms of gas are moving toward the observer the radiation is slightly bluer than normal. In the aurora's case, it is slightly bluer, so we conclude that we are seeing the direct effect of protons impinging on the upper atmosphere with high speed.

Auroral theories. For these basic facts we would like to find an explanation. Even before the discovery of hydrogen lines in the spectrum, by L. Vegard in 1939 in Norway, and of the Doppler shift of the hydrogen lines, by A. B. Meinel at Yerkes Observatory in 1951, charged particles from the sun were suspected as the cause of aurorae. The auroral zones are roughly symmetrical about the geomagnetic poles, which suggests that charged particles are guided to earth by the magnetic field. The relationship between solar and geophysical activity suggests the sun as the source of these particles. Although it has never been proved that solar particles produce aurorae, several theories have been put forth attempting to explain the aurora as caused by hydrogen gas thrown out of the sun and reaching the earth a day or so later.

The hydrogen atoms ejected from the sun are presumably *ionized*, that is, in each atom the proton and electron are separated, so the one is no longer bound to the other. One of the major questions in this kind of theory is whether the positively charged protons and the negatively charged electrons travel together toward the earth in a large cloud, or whether the hypothetical stream contains particles of one sign moving faster than those of the other sign. In the latter case, the solar stream would carry an electric current, which would play a role in the effects of the stream upon the earth.

When one of these hypothetical streams of gas gets close to the earth, it encounters the terrestrial magnetic field. As the charged particles try to move into the field, strange and complicated effects may occur, depending on the properties of the stream and, hence, on the manner in which the gas and the earth's magnetic field interact.

Any theory of this sort should answer two questions. First, some of the solar particles do get through the terrestrial magnetic field; would this high-speed bombardment be sufficient to cause the glow in the upper atmosphere that we call the visible aurora? Second, the magnetic field undergoes small changes during an aurora; can these changes be explained by the gas stream colliding with the earth?

As far as the aurora is concerned, most theories have dealt primarily with the problem of getting fast particles from the sun into the earth's upper atmosphere. It is generally presumed that if the particles can get this far, surely they will produce the observed phenomena. This assumption seems somewhat unsatisfactory, although without adequate data it is the best that can be done. A more promising approach might be to deduce the nature of the particles, or other source of energy producing the light, from measurements of the auroral luminosity. But at present we are only beginning to obtain a sufficient amount of observational data.

Generally, auroral theories have assumed that the solar particles move through a vacuum between the sun and the earth and, especially, that the region around the earth is a vacuum. But recent studies of the polarization of the zodiacal light, and the propagation of radio signals called *whistlers* along the magnetic field of the earth between the Northern and Southern Hemispheres, have shown that interplanetary space near the earth is not completely empty; instead it contains something like 10,000 electrons and protons per cubic inch.

While this concentration of ionized matter is extremely low by laboratory standards, it is sufficient to have a profound effect on the behavior of any stream of gas passing between the sun and the earth. For example, if a cloud of ionized gas moved into the earth's magnetic field in a vacuum, electric currents would be induced on the surface of this cloud. These currents would in turn produce a small magnetic field that would slightly distort the general magnetic field of the earth. But a conducting interplanetary medium might shield the surface of the earth from the effects of these extraterrestrial currents. Therefore, the presence of the interplanetary medium would greatly complicate the behavior of a stream of gas as it approached the earth, and is an additional factor to be considered in any theory about the origin of the aurora.

(To be continued)

Another photograph by the author, of a January aurora in Alaska.

The astrophysicist G. A. Shajn, who was a leading figure in Russian astronomy for the first half of the 20th century.

G. A. Shajn and Russian Astronomy

OTTO STRUVE, *Leuschner Observatory, University of California*

LAST AUGUST I visited Belgium, to attend a meeting at Liege of the executive committee of the International Astronomical Union. There I had several long talks with the vice-president of the union, Prof. B. V. Kukarkin, who is a variable star specialist at the Sternberg Astronomical Institute in Moscow.

On one occasion we were discussing my article in the June, 1957, *Sky and Telescope*, about the fate of the great Russian astronomer B. P. Gerasimovich. Kukarkin said he could not agree with all my statements, but assured me that the name of Gerasimovich had already been restored to good standing in the Soviet Union, long after the cruel punishment he had suffered in the great purge of 1937. And then Kukarkin made a significant comment. As I remember it, he spoke about as follows:

"Gerasimovich was essentially a pessimist, and I disagreed with his despairing attitude toward the advance of astronomy in Russia. He always insisted we could never overcome the enormous lead of American astronomers; yet today, only 20 years later, we are already ahead of you in some fields." As he spoke, Professor Kukarkin probably knew what I did not know, that a Russian artificial satellite was then in the making, and that it might be in its orbit long before the first American satellite.

Then Kukarkin described to me the chaotic plight of Russian astronomical institutions in the early 1920's, after the first world war and the civil war. Research at the observatories had virtually come to a standstill. Almost all the younger astronomers had been called into military service, and many had died or had entered other fields of activity. The older astronomers were trying to support their families by raising vegetables in the observatory gardens, or by working as laborers. Many eked out a living by selling their personal belongings in the black market.

Those were the times when the observatory buildings and even the residences of the astronomers remained unheated during the long and severe Russian winters; the water mains would stay frozen for weeks at a time. Often there was no electricity through the long hours of darkness. Many people perished during the terrible famines that followed one another after the end of the revolution.

The great Poulkovo Observatory had been seriously damaged in the battles between the Bolshevik and White Russian armies near Petrograd; and its Crimean branch station at Simeis had been cut off from all contact with Poulkovo for several years during the civil war. Astronomy had to be rebuilt almost from scratch. Older observatories had to be restaffed and re-equipped, and new institutions had to be created to meet the challenge of western scientific advances.

How was this miracle of rejuvenation of astronomy in Russia accomplished? It seems to me that much of the credit belongs to a small number of devoted scientists who were old enough to have received most of their training in the great Russian universities before the outbreak of the war in 1914, yet young enough to be receptive to the new astronomical ideas that had sprung up in England, America, and elsewhere between 1914 and 1920. Among these astronomers was G. A. Shajn, whose death on August 4, 1956, ended a remarkable career.

Grigorij Abramovich Shajn was born on April 13, 1892, at the Black Sea city of Odessa, the son of a poor carpenter. Since his father could not afford to pay his tuition for high school, Shajn studied at home, and in 1911 passed the examinations for his high school certificate.

Shajn's interest in astronomy, like that of many other young Russian and French students, was aroused by reading Camille Flammarion's novel *Stella*. At the age of 14 or 15 he began observing meteors from the roof of the family's house. His first astronomical article, on determining the radiant point of the Perseid meteor shower, was published in 1910 by the Russian Astronomical Society.

Two years later he enrolled as a student at the Estonian University of Yurjev (formerly Dorpat, now Tartu). There he devoted himself to mathematics, physics, and astronomy. But in 1914 young Shajn, animated by the patriotic feeling that swept the entire country, enlisted as a volunteer in the Czarist army and served at the front until 1917.

After the revolution, he went to the University of Perm in eastern Russia, and in 1920 was granted the degree of Magister (about the equivalent of a Ph. D.). During a year's work at the University of Tomsk, in Siberia, he met and married Pelageya Feodorovna Sannikova, who became an astronomer in her own right, and shared with her husband all his later activities. She died only three weeks after him.

Shajn's great ability received recognition in 1921, when he was appointed to the staff of the Poulkovo Observatory. During the next three years he worked principally in the field of celestial mechanics. His most important investigation then was a study of the perturbations produced by the earth upon the orbits of meteor streams. This work — little known outside Russia — was published by the Poulkovo Observatory in 1924. In it Shajn investigated theoretically how a compact stream of meteors is dispersed as a result of the attraction by the earth.

Different streams, he found, are scattered at different rates. For example, the Perseids are being dispersed very slowly, while the meteors of the Bielid stream experience large orbital changes. As a rule, the perturbations in celestial (ecliptic) longitude are larger than those in celestial latitude. Finally, Shajn predicted that perturbations could split off part of a strong stream, to form an independent meteor shower with its own radiant.

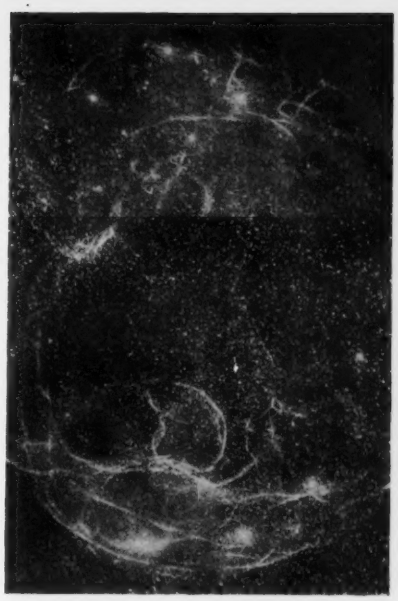
In 1924 Shajn was placed in charge of the Simeis Observatory's new 40-inch reflector, which had been constructed in England after the end of the war. With this instrument he carried out many investigations of stellar spectra, the radial velocities of stars, orbits of spectroscopic binaries, and related programs. This work continued until 1941, when the invasion of the Crimea by the Nazi army resulted in the complete destruction of the observatory and the 40-inch telescope. During this long and fruitful period up to 1941, one of Shajn's most significant contributions was his paper, "On the Rotation of the Stars," published in the January, 1929, issue of the *Monthly Notices* of the Royal Astronomical Society, and in which I had the pleasure of collaborating.

We had never met while I was still living in Russia. But we started corresponding with one another as a result of the informal American committee, organized by E. B. Frost of Yerkes Observatory, for the relief of Russian astronomers during the worst of their famines. I acted as committee secretary, and to me fell the duty of collecting information about the needs of the various groups of astronomers, and of mailing them food packages through Herbert Hoover's American Relief Administration.

Through our letters, Shajn and I soon found that we had been independently working on the problem of stellar rotation, and so we decided to pool our results. The problem was then a new one, and most astronomers were inclined to believe that rotation played little part in causing the broadness and diffuseness of the absorption lines in the spectra of many early-type stars. Shajn made an ingenious study of the spectrum lines in the integrated light of the planet Jupiter. These lines could be compared with those observed in the spectrum of direct sunlight. In this way, he demonstrated that the 25-kilometer-per-second equatorial rotation of Jupiter produced precisely the kind of broadened lines I had observed in many stars.

Most of our results were concerned with the rotations of the component stars of spectroscopic binaries. Shajn predicted the profiles of the absorption lines in several eclipsing binaries — predictions since confirmed by direct observation. While in our 1929 paper we did not specifically discuss the rotations of single stars, we both realized that rotation could account for the broadened absorption lines in the spectra of many of them, as well as in the spectra of close binaries. In our later investigations, published separately, we found that for single stars fast rotations occur almost exclusively among main-sequence objects of spectral types earlier than *F5*.

In 1925 Shajn spent several months in England, partly in connection with the organization of astrophysical work at Simeis. That same year he discovered a new comet, under curious circumstances which he described in a letter to me. Among his tasks at Simeis was sharing in the photographic observations of minor planets, using one of the smaller instruments. It was the practice at that observatory to move the plateholder during the exposure in a direction and at a rate computed to follow the motion on the sky of an average asteroid. (In this way, the photograph would show asteroids as points and stars as short trails.) But Shajn, who had only recently arrived from Poulkovo, made a mistake; he shifted the plateholder at the computed rate but in the opposite direction. The resulting motion, though wrong for the asteroids, happened to be nearly correct for the comet! I do not know if the comet image would have been undetectably faint had Shajn shifted the plateholder in the correct direction.



A Simeis Observatory photograph of the filamentary nebulosity associated with Nova Aurigae 1891, a star that attained the 4th magnitude. The heavy concentration of nebulous matter near the bottom of the field is nearly four degrees from the nova's position.

The 40-inch reflector at Simeis Observatory, destroyed in World War II.

Shajn was a member of the delegation of Soviet astronomers who went to Copenhagen in March, 1946, for a meeting of the executive committee of the IAU. This conference had been convened by the president, Sir Harold Spencer Jones, in order to resume the activities of the IAU after the second world war. It was on this occasion that I met Shajn and his wife for the first time. The next year he visited the United States, and during his stay at McDonald Observatory Shajn and I resumed our collaboration. With the 82-inch reflector, we observed the spectra of several *N*-type stars in the violet region, obtaining measurements of the deep absorption at wave lengths just short of 4100 angstroms.

During the last years of his life, the Soviet astronomer worked almost exclu-

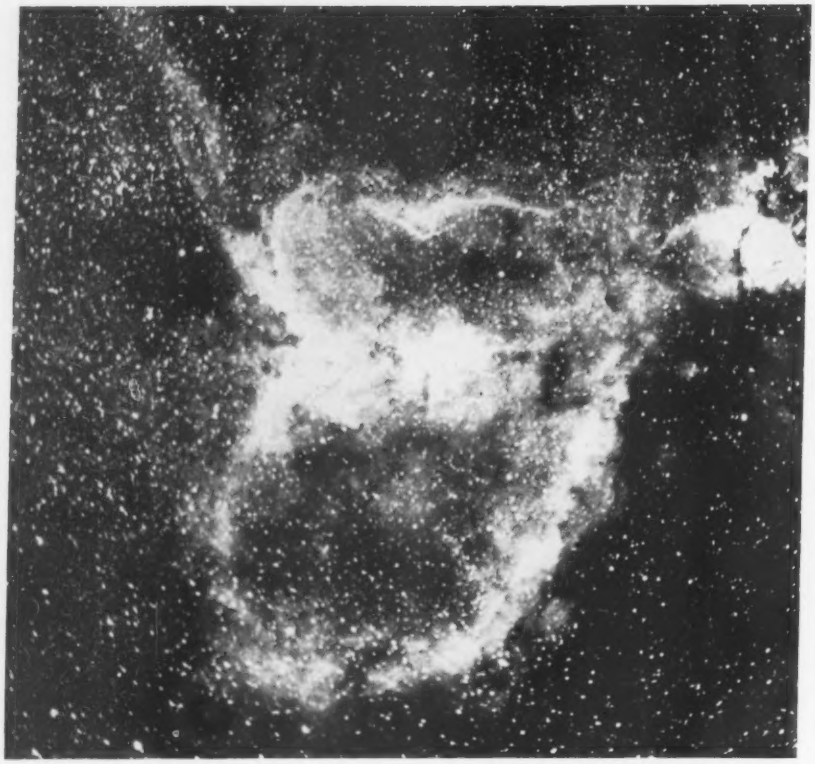


Plate 1 of the Shajn-Hase atlas of nebulae is here reduced to two-thirds original size, the new scale being 1.2 minutes of arc per millimeter. It was taken with an f/1.4 Maksutov camera, and north is at the top. Centered is the striking nebulosity IC 1805, involved with the open cluster Melotte 15, at galactic longitude 102° on the galactic equator in southeastern Cassiopeia. In the upper right is the nebula NGC 1795, and at the upper left the cluster NGC 1027. The center of the field has the 1900 co-ordinates $2^h\ 25^m$, +61°.

sively on the distribution of faint galactic nebulae. He obtained two very fast meniscus-type cameras, and started a systematic photographic survey of the Milky Way in the light of the red line of hydrogen. His *Atlas of Diffuse Gaseous Nebulae,* published jointly with Miss V. F. Hase, contains many new nebulosities. Of special interest are the filamentary structures of long narrow wisps that he and Miss Hase discovered. Their results on the orientations of the wisps with respect to the galactic equator, and the relation of these orientations to the general magnetic field of the Milky Way, formed the substance of Shajn's last scientific articles, in 1956.

In the summer of 1954, Shajn had traveled to Belgium to attend an international symposium at Liege devoted to nuclear processes in stars. He was already a very sick man, and told his many foreign friends he did not expect to see them again. His companion and colleague, V. A. Ambarzumian, watched over him to make sure that he did not overtax his weak heart.

Shajn served as director of the Simeis Observatory until 1952, when he asked to be relieved from the heavy project, started in 1946, of rebuilding the observatory at its new site, Partizanskoye (*Sky and Telescope,* October, 1955). According to the recent biography of Shajn by his associate, S. B. Pikelner, a reflecting telescope of 102 inches aperture to be installed in the new observatory will bear Shajn's name.

Important as Shajn's scientific work has been to astronomers of all countries, I believe he will be remembered principally for his part in rebuilding the entire structure of astrophysical research in the Soviet Union. His influence was greatly enhanced by his quick appreciation of the significance of new discoveries.

Yet he was a modest man, and outward recognition meant little to him. To my recollection, he was never involved in scientific or personal controversies. He ignored his critics, and kept right on doing what he thought necessary for the advancement of knowledge. There is little doubt that he was beloved not only in Russia but among the astronomers in other parts of the world who knew him.

For much of the history of Professor Shajn, I am indebted to P. G. Kulikovsky, editor of Vol. 3, *Investigations into the History of Astronomy,* which contains Pikelner's biography of Shajn. Shorter obituary articles on Shajn and Mrs. Shajn have appeared in the Crimean Astrophysical Observatory's *Annals,* Vol. 17.

NAVAL OBSERVATORY DOUBLE STAR PROGRAM

The latest number of the *Publications* of the U. S. Naval Observatory reports an extensive series of filar-micrometer measurements on close double stars, made by William Markowitz with the 26-inch Clark refractor. Details are given of 1,826 measures of 648 pairs, on 150 observing nights between October 10, 1949, and November 18, 1952.

Dr. Markowitz made systematic reobservations of close double stars for which few measures exist, including many binaries in rapid orbital motion. Although some of these pairs were being measured by G. Van Biesbroeck at Yerkes and McDonald Observatories, there was little danger that they would be observed too frequently – few astronomers carry on such work at present.

It had come to be thought that deteriorating atmospheric conditions in the city of Washington, D. C., had made it impractical to measure very close double stars. Yet Dr. Markowitz found that the practical limit of separation for measurement with the 26-inch was as small as 0.15 second of arc. For the more difficult pairs, he used powers of 1,300 to 2,000, and for some experiments even 4,000.

Only a small portion of the average year's clear or partly clear nights in Washington had seeing good enough for this work. One or more measures were made on about 50 nights per year, but on only about 20 nights per year were 15 or more pairs observed, accounting for 80 per cent of all the measurements in the program of Dr. Markowitz.

Although the Barlow lens is a familiar accessory among amateur observers, surprisingly little use of it has been made by double star observers with large refractors. The Barlow employed by Dr. Markowitz was a lens of 12.5 millimeters negative focal length, and when placed in front of the eyepiece increased the magnification 3.3 times. This arrangement proved quite satisfactory when very high powers were needed.

An important part of Dr. Markowitz's undertaking was a study of the optical properties and performance of the 26-inch objective lens, which he reports in full. The resolving power of a telescope for visible light is predicted by Lord Rayleigh's formula as $5''.03/A$, and by Dawes' formula as $4''.56/A$, where A is the aperture in inches. However, these predictions do not refer, in the case of a double star, to completely separated images of the two components, but to merged images.

For a 26-inch telescope, the Rayleigh and Dawes limits are $0''.19$ and $0''.18$, respectively. Double stars whose components had such separations were observed as "notched" by Dr. Markowitz. Wider pairs, averaging $0''.23$, were noted as just in contact, and $0''.26$ doubles were seen as just separated.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 99th meeting of the American Astronomical Society at Indianapolis, Indiana, in December, 1957. Complete abstracts will appear in the Astronomical Journal.

Cosmic Distance Scale and the Red Shift

One of the most fundamental problems in astronomy — the scale of distances of the galaxies — had apparently been solved by 1936, as a result of Edwin P. Hubble's observations with the 100-inch telescope at Mount Wilson Observatory. But today the whole subject of the cosmic distance scale requires thorough restudy, and this has been one of the most important tasks of Palomar Observatory and its 200-inch Hale reflector.

The current status of this work was reported by Allan R. Sandage, of Mount Wilson and Palomar Observatories, in his Warner lecture before the American Astronomical Society. The prime importance of accurate distances, he pointed out, lies in the calibration of the relationship between apparent velocity of recession and distance for the galaxies. In 1936, Hubble had estimated that the average rate of recession increased 540 kilometers per second for each million parsecs. If the numerical value of this Hubble constant were precisely known, together with its rate of change with time, then in principle we should be able to decide which of the various theoretical "world models" corresponds to the actual universe.

The rate of change of the Hubble constant with time should be determinable from measurements of the red shifts in the spectra of very distant galaxies, which we observe by the light that left them ages ago. In Dr. Sandage's words, "We look back in time as we look out in space." But only for the nearest galaxies can we hope to determine reliable individual distances, and for most of these objects the systematic red shifts are small and are masked by random space motions. On the other hand, for galaxies so remote that the red shifts dominate the random motions, we can obtain only indirect and uncertain distance data. Even the 200-inch telescope can bridge this gap for only a few galaxies.

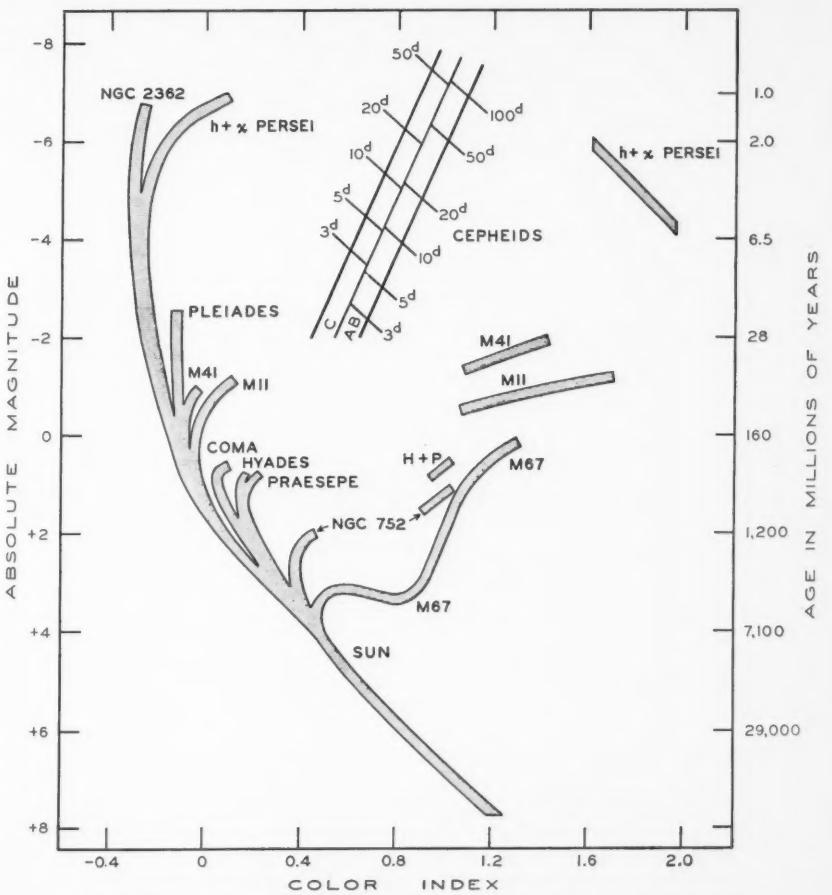
In his lecture, Dr. Sandage re-examined critically Hubble's criteria for setting up the distance scale. Hubble had established the distances of the nearby systems, including M31 and M33, by using the apparent brightnesses of their Cepheid variables, stars for which the period of light fluctuation is longer the greater the intrinsic luminosity. In other galaxies that were somewhat more remote, Hubble could observe individual stars of high luminosity, a second yardstick for establishing distances. In a further step outward into space, he used these galaxies to calibrate a relationship between total apparent magnitude and distance, which could be applied to still more remote systems.

As Hubble himself had suspected might be necessary, many of his assumptions later needed revision, especially when by 1952 W. Baade and others demonstrated that the Cepheid variables were about four times as luminous — and twice as distant — as had been believed.

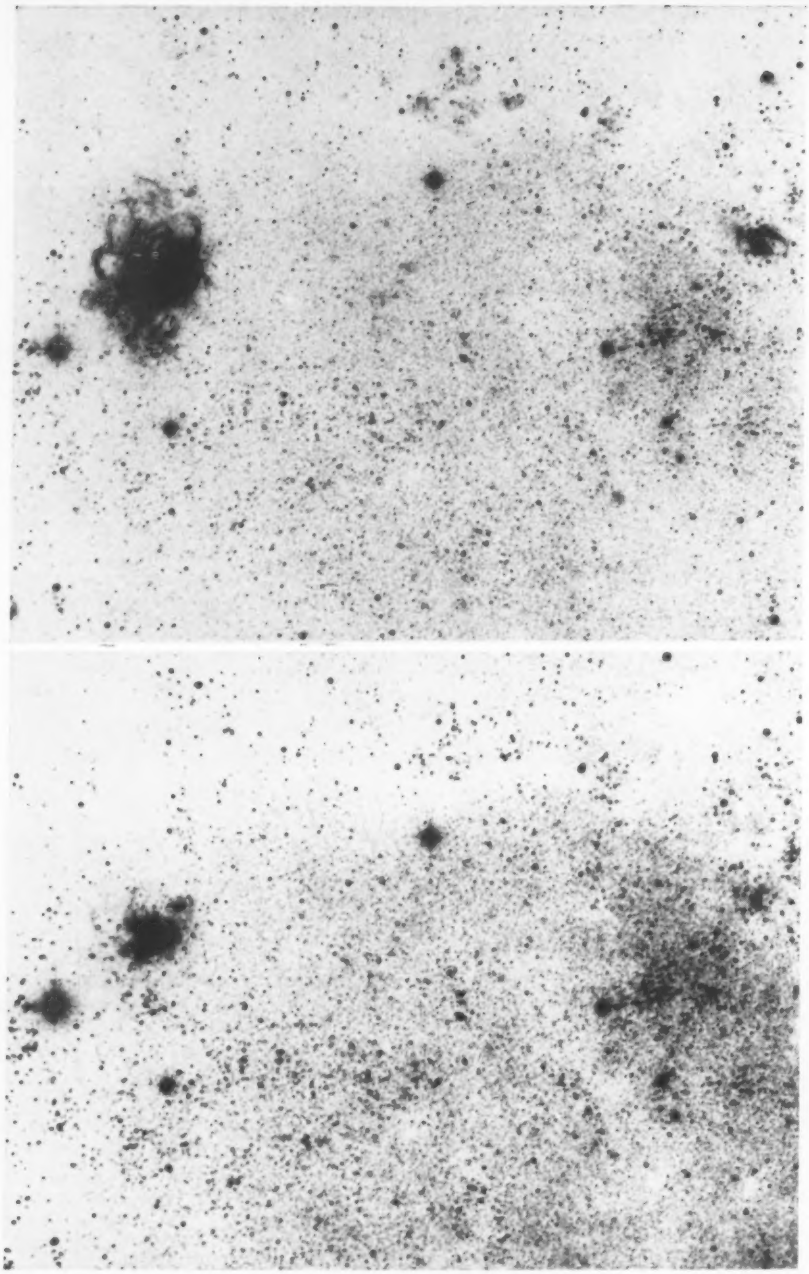
For many years, it had been believed that the period of a Cepheid variable accurately specified its intrinsic luminosity — for example, one could compute the distance of the Andromeda galaxy from the observed period and apparent magnitude of a Cepheid in it. Most investigators realized, with Harlow Shapley, that a large scatter existed in the period-luminosity relation for the Magellanic Clouds, but had assumed that this scatter came from observational uncertainties and from absorption by dust inside the clouds.

In 1955, however, Halton C. Arp proved that Cepheids in globular clusters can have a spread of more than one magnitude at a given period. The precision of his photometric observations was very high, so observational scatter could be excluded from consideration. He showed, further, that the globular cluster Cepheids obey a period-luminosity relation at least 1.5 magnitudes fainter than the law for the classical Cepheids. And from recent two-color work in the Small Magellanic Cloud, Arp has found that Cepheids of the same period can differ in color by as much as 0.2 magnitude (blue-yellow color index). From this, Dr. Sandage could calculate that the absolute magnitudes of Cepheids with the same period have a spread of 1.2 magnitudes.

Thus, the Cepheid period-luminosity "curve" now seems to be actually a broad band. In the Andromeda galaxy, M31, such a spread had been observed in 1955



The Cepheid-variable region is plotted by A. R. Sandage on this composite color-magnitude diagram for galactic clusters. The two groups of Cepheids (called C and A-B by O. Eggen) have very different period-luminosity relations. Mount Wilson and Palomar Observatories chart.



This pair of photographs with the 200-inch Palomar telescope shows part of the spiral galaxy M33 resolved into starclouds and nebulosities. Stars appear black in these negative reproductions. The upper picture was taken in hydrogen-alpha (red) light, the lower in yellow. The hydrogen emission patches in the red picture do not show in the yellow. However, NGC 604, the large H-II region at the left, also shines partly by reflected starlight, and therefore is distinctly recorded in yellow. North is at the top. Mount Wilson and Palomar Observatories photographs.

by Baade and Henrietta Swope, but they had interpreted it as due to varying amounts of dust-cloud absorption inside that system. Some of the spread in M31 is undoubtedly due to dust absorption, but intrinsic spread in the period-luminosity relation may be as important an effect.

This scatter in the period-luminosity relationship greatly complicates distance determinations of nearby galaxies from their Cepheids, particularly if the relationship should turn out to differ from galaxy to galaxy. Dr. Sandage stated that probably we do not yet know the distance modulus (apparent minus absolute magnitude) of M31 to better than ±0.5 magnitude from the Cepheid criterion alone. It will be necessary to devise a new method, perhaps utilizing the shape of the light curve as an additional source of information, to tell whether an individual Cepheid happens to be overluminous or underluminous for its period.

Thus, although the 200-inch telescope has increased the range of detection of Cepheid variables beyond galaxies in the local group (30 calibration systems now being available instead of seven to Hubble with the 100-inch), Dr. Sandage considers Cepheids to be unusable at this time except for relative distances. To set the zero point of the distance scale, he uses only the apparent magnitudes at maximum light of the novae appearing in the nearest galaxies, adopting the results of recent work by T. Schmidt and Arp. Schmidt's distance modulus for the Magellanic Clouds is 19.2, and 24.6 for M31, corresponding to distances of 230,000 and 2,600,000 light-years, respectively (uncorrected for absorption).

Dr. Sandage next analyzed Hubble's second step. Hubble had observed, in those galaxies near enough to us to be partially resolved into stars with the 100-inch telescope, objects that he believed were the counterparts of the very hot and luminous blue stars in our own Milky Way system. On this interpretation, he used these objects as distance indicators.

But now, with the aid of the 200-inch telescope, Dr. Sandage finds that Hubble mistook other objects for the individual "brightest stars." Photographs in red light show many of them to be H-II regions — huge luminous patches of ionized hydrogen gas.

An example of an H-II region in a nearby galaxy is NGC 604 in M33, a galaxy so close (it is within the local group) that no misidentification of the nature of NGC 604 is possible. But if M33 were placed at 10 times its actual distance, special techniques, such as photography in the red light of $H\alpha$ emission, would be needed to tell that NGC 604 is an H-II region rather than a very bright star. Furthermore, only on nights of exceptional seeing could the disk of NGC 604 then be resolved with the 200-inch telescope or possibly with the 120-inch of the Lick Observatory. The modern technique of $H\alpha$ photography was not available in practical form in the 1930's when Hubble was working on the calibration problem. Dr. Sandage emphasized that no criticism of Hubble's basic approach is warranted. Rather, the recent developments in the calibration problem show the improvement in the detection of light in the red spectral regions since the 1930's.

The Warner lecturer then turned to Messier 100, the brightest galaxy of type Sc (open spiral) in the Virgo cluster of galaxies, at a distance he now finds to be on the order of 10 million parsecs. This is about 10 times the distance to M33. There are a number of knots along the spiral arms of M100 that look, without further evidence, like images of bright stars. But the 200-inch photographs show

these knots to be H-II regions, like NGC 604. The stars themselves appear only at photographic magnitude about 20.8, but this is 1.8 magnitudes fainter than Hubble's value of 19.0. All other distant galaxies for which the necessary 200-inch plates have been assembled show the same effect. Thus, most of the knots identified in 1936 as stars appear to be H-II regions.

If this difference of 1.8 magnitudes between H-II regions and brightest stars holds for galaxies generally, and if these stars have an average absolute magnitude of −9.5, then the galaxy distances are almost 10 times greater than on the old distance scale of 1936. This argument gives the value of the Hubble recession constant as only 55 kilometers per second for each million parsecs of added distance, but becomes 87 if the above absolute magnitude is instead −8.5; both choices are plausible.

For Messier 87 in the Virgo cluster, Dr. Sandage notes that a distance of approximately 13 million parsecs (45 million light-years) follows from magnitude measurements in 1955 by W. A. Baum. He found that the globular clusters in M87 are six magnitudes fainter than those in the Andromeda galaxy. The Hubble constant on this basis would be about 83 kilometers per second for each million parsecs.

"These arguments do not constitute a rediscussion of the distance scale," the California astronomer pointed out. "Precise new measurements are required for this." They do, however, suggest that the 1936 distance scale of Hubble must be increased by a factor of five to 10.

This implies that the expansion of the universe has been under way for longer than has been hitherto believed. The calculation of the expansion age depends on the choice of the cosmological model. For the one particular model of flat Euclidean space, the age of the universe would be 13.3 billion years if the Hubble constant were 50, and 6.6 if it were 100. Both values are in the same general range as the age of seven billion years indicated by the heavy elements of the universe, as very recently calculated by the Burbidges, W. A. Fowler, and F. Hoyle.

The current program at Palomar Observatory for the recalibration of the Hubble constant calls for new observations and interpretation of the Cepheid criterion within the local group. It involves isolation and photometry of stars and H-II regions in all galaxies of types Sb, Sc, SBb, SBc, and Irr, north of declination −15°, that have red shifts between 500 and 2,000 kilometers per second. The brightest-star luminosities will be determined anew, for different types of galaxies, in the 30 nearby systems where the Hale reflector can reveal Cepheid variables. Dr. Sandage pointed out that this far-reaching project has only just begun and that until the results are available all estimates of cosmic distances are unsure.

Cepheid Symposium

At a special session on variable stars of the classical Cepheid type, five astronomers told of current researches, including work in the southern sky. The moderator of the symposium was Allan R. Sandage, Mount Wilson and Palomar Observatories.

The best-known Cepheid variables in the sky are Delta Cephei (after which the class is named) and Eta Aquilae. At David Dunlap Observatory, J. B. Oke has been using a new photoelectric spectrometer to measure their light intensities at 21 wave lengths between 3400 angstroms in the ultraviolet and 5200 angstroms in yellow. The spectrograph has to be operated without a slit, and the resolution achieved is about seven angstroms.

In this way, Dr. Oke has secured for each star 21 light curves at as many different wave lengths. The amplitude of light variation changes markedly with wave length. For Eta Aquilae, the light range is 0.9 magnitude at 5200 angstroms, gradually increasing to a maximum of 1.8 magnitudes at 3850, then falling rapidly to 1.2 magnitudes at shorter wavelengths. The amplitude-wave length curve for Delta Cephei is almost identical with that of Eta Aquilae.

An important object for distance-scale calibration is the Small Magellanic Cloud, at present believed to be about 230,000 light-years from us. Over 1,000 Cepheid variables in it have been studied photographically. Halton C. Arp, Mount Wilson and Palomar Observatories, told of his latest work. He first established a sequence of photoelectric magnitudes containing 27 stars, to as faint as blue magnitude 20.1, in the region of the star cluster NGC 419 in the Small Cloud. He then used this sequence to calibrate photographic magnitudes of stars in and near the cluster. The color-magnitude diagram of the cluster is roughly equivalent to that of a globular cluster at the Small Cloud's distance, but there is a puzzling break in the giant branch on the diagram. It is not certain whether NGC 419 is a globular or some other type of cluster.

Early in 1955, John B. Irwin, of Indiana University's Goethe Link Observatory, was on an expedition to South Africa to measure photoelectrically the brightnesses and colors of Cepheids in the southern sky. Altogether, about 1,700 three-color observations of 145 Cepheids were secured with the 24-inch refractor of the Cape Observatory and the 74-inch Radcliffe Observatory reflector. Dr. Irwin was able to deduce photometric distances of 123 of these stars.

It was found that the dimming of light by interstellar dust amounts to only about 0.5 magnitude per 1,000 parsecs in the constellations Puppis and Carina, close to the galactic equator. In these directions, therefore, space is more nearly transparent than elsewhere along the Milky Way. Through this "window" a number of Cepheids more than 13,000 light-years away were observed, one of them, CT Carinae, being perhaps 32,000 light-years from us.

The distribution of the southern Cepheids shows some slight indication of the spiral structure of our Milky Way system. In particular, an apparent inner spiral arm outlined by Cepheids with periods shorter than 10 days may be only 2,000 light-years distant.

Another Indiana astronomer, Robert P. Kraft, discussed the classical Cepheids that are members of galactic star clusters. This subject has aroused widespread interest since Dr. Irwin's discovery during his South African work that two stars of this type, U Sagittarii and S Normae, are members of the open clusters M25 and NGC 6087, respectively.

The importance of this finding is twofold. First, the distances of galactic clusters can nowadays be measured with some precision, so the existence of Cepheids within them provides a new method for determining intrinsic Cepheid brightnesses. Dr. Kraft has made use of four such cluster members to ascertain that classical Cepheids average 1.2 magnitudes brighter than given by H. Shapley's historic period-luminosity curve.

In the second place, new information about the evolution of Cepheid variables is made available. Three of the galactic clusters containing Cepheid variables (including M25 and NGC 6087) appear to be about 100 million years old, a fourth cluster about 200 million. Thus it seems that the age of the typical Cepheids is also about 100 or 200 million years. Dr. Kraft believes that the variables with shorter periods may be older stars than those with longer periods.

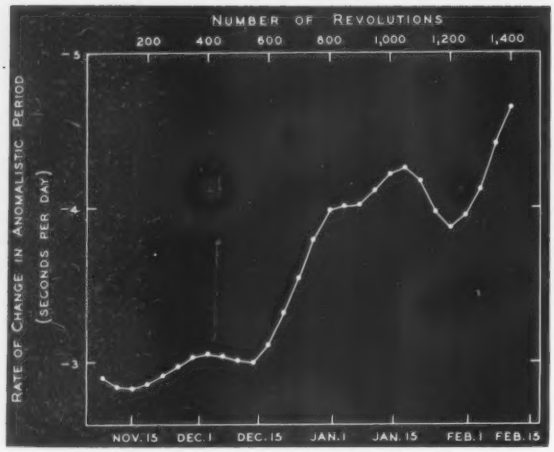
Charles A. Whitney, Smithsonian Astrophysical Observatory, the fifth symposium speaker, described his theoretical studies of pulsating gas spheres, such as Cepheids are believed to be. Pulsation may be maintained by varying of nuclear energy generation in the stellar interior; another mechanism might be the setting up of a "heat engine" in the external layers through the action of varying opacity of the star's material and heat storage.

WILFRED HALL OBSERVATORY

In 1952, the British Astronomical Association was obliged to decline the bequest of the twin 15-inch refractor that had belonged to the English amateur, Dr. Wilfred Hall; the cost of erecting and maintaining the instrument, consisting of visual and photographic telescopes on the same mounting, was deemed too great.

Now, however, this refractor has been re-erected by the municipality of Preston, Lancashire, England. Renovation of the instrument and the new building for it cost £6,000. The new Wilfred Hall Observatory is under the directorship of Dr. V. Barocas, and its facilities will be available for research by amateurs.

Some Satellite Notes



The period of Sputnik II was shortening by from three to five seconds per day, in this Smithsonian diagram by L. G. Jacchia. (Anomalistic period is the interval between successive perigee passages.)

The Erratic Orbital Acceleration of 1957 Beta

AS IS WELL KNOWN, atmospheric resistance causes artificial earth satellites gradually to spiral in, thereby shortening their periods of revolution. The drag force exerted on a fast-moving body in a rarefied atmosphere is very nearly proportional to the product of the atmospheric density, the square of the velocity, and the ratio of the body's cross-sectional area to its mass.

If the satellite is a perfect sphere, this last quantity, the mass-area ratio, is constant in the course of a revolution, and the drag can be expected to increase rather uniformly with time as the orbit shrinks into increasingly dense regions of the atmosphere. For such a satellite we may expect to find a reasonably uniform acceleration in the orbital motion.

There are, to be sure, long-term perturbations of the period caused by the earth's oblateness, and oscillations caused by the motion of perigee in an atmosphere that bulges at the equator, as well as irregular fluctuations from day-to-day variations in the density of the upper air, and there may even be variable electric and magnetic drag effects. All these irregularities, however, are expected to have only a relatively minor, or at least slow, effect on the over-all acceleration — with the exception, perhaps, of the day-to-day density variations.

Conditions can be quite different when the satellite is an elongated object, like the carrier rocket of Sputnik I, the entire body of Sputnik II, and the first American satellite, Explorer. As such a pencil-shaped object tumbles and yaws along, the area presented by its forward surface varies all the time, and we can expect both random and systematic deviations from the mean cross-sectional area. The drag effect will vary accordingly. Probably each time the satellite passes through the denser layers near the perigee of its orbit, its orientation is altering from point to point. If the changes in orientation from one revolution to the next vary in a completely random fashion, the effect on the total drag will be small, but if these changes have a systematic character, their effect could be quite considerable. This could well be, I think, the explanation for the marked, irregular fluctuations that the orbital acceleration of the second Russian satellite, 1957β, has exhibited.

An alternate explanation for these fluctuations lies in erratic day-to-day variations of the density of the upper-atmospheric layers. In view of the extremely low density prevailing at the perigee height of 1957β (one 100-billionth of the sea-level atmospheric density), the possibility of rapid density changes of 10 per cent over much of the globe should by no means be excluded. If both spherical and elongated satellites exhibit the same type of erratic fluctuations in their accelerations, then this will turn out to be the true explanation. Unfortunately, the observational material collected on 1957α2 does not seem to be numerous and accurate enough to decide this question.

The accelerations plotted in the chart above were obtained from an analysis of more than 1,000 MOONWATCH and radio observations of the positions of 1957β. The probable errors of the plotted points are quite small, of the order of ±0.03 second per day. Particularly noteworthy are the dip in the acceleration in the second half of January and the rapid recovery following it. That is, in the second half of January, when we might have expected the period to decrease by 4.2 seconds per day or more, it actually shortened by a smaller amount, as little as 3.9 seconds near the end of the month. Then the acceleration increased very quickly, its value reaching 4.4 seconds per day at the end of the first week of February.

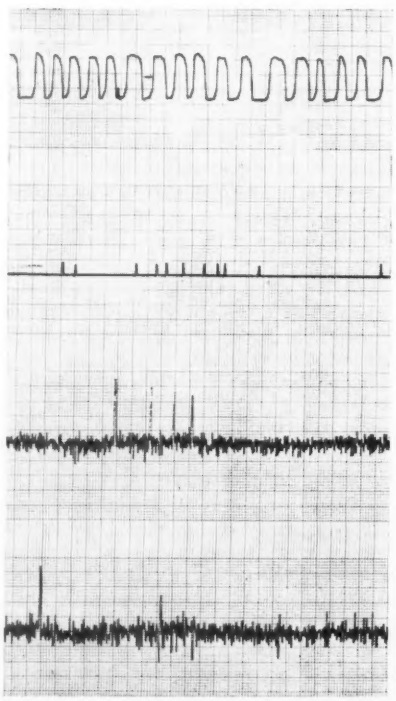
These rapid fluctuations make it clear that accurate long-range predictions are impossible for satellites of this type. Suppose that February predictions of the times of visibility of Sputnik II had been made on the basis of the observed accelerations during the second half of January. Due to the ensuing upswing of the acceleration at the beginning of February, the predictions would have been in error by two minutes at the end of one week and by 17 minutes at the end of the second week.

It is impractical for the Smithsonian Astrophysical Observatory headquarters to reach all MOONWATCH teams by wire, so we must rely on the mails for sending out predictions, which therefore extend over periods of approximately 10 days. It is easy to see, from the foregoing facts, why the predictions may be in error by a few minutes at the end of such a 10-day ephemeris.

LUIGI G. JACCHIA
Smithsonian Astrophysical Observatory

Explorer I Radio Signals

THE National Capital Astronomers and the U. S. Army's Diamond Ordnance Fuze Laboratories joined in producing the accompanying record of the first Explorer's message. It was made on the evening of February 6th, at the society's MOONWATCH station in Silver Spring, Maryland, by leader G. R. Wright. The



During its early life, the first American satellite broadcast on four information channels, transmitting data (top to bottom) on cosmic-ray incidence, micrometeorite impacts, external casing temperature, and internal temperature of the transmitting compartment. Diamond Ordnance Fuze Laboratories chart.

60 milliwatt signal of the 108.03-megacycle transmitter was picked up with a five-element yagi antenna on an altazimuth mounting; the signal was fed to a cascode converter, then to a BC-348 receiver, and finally was tape recorded.

Under the direction of H. V. Menapace, the tape was processed by C. L. Massey at the laboratories' missile-telemetry station, where the information channels were separated and recorded on a paper chart.

The four channels show, from top to bottom: 1, cosmic rays, recorded as a "step" for every 32 detected; 2, meteoroid impacts, none shown here; 3, rear external casing temperature (calibration, not shown, is needed for interpretation); and 4, internal transmitter compartment temperature, calibration also needed. Each major division, containing five smaller divisions, represents one second of time; the jagged traces are radio noise.

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Washington 25, D. C.

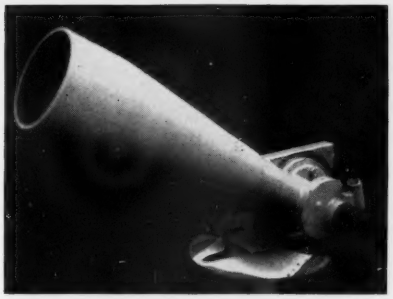
Observing-Instrument Modifications

SIX MONTHS' experience in the visual tracking of artificial satellites has indicated the need for specialized instruments for orbiting bodies with different characteristics. For example, the first two bright Russian satellites could be tracked accurately in instruments of narrower field but higher magnification than standard MOONWATCH telescopes. For the latter, the required routine accuracy is only one degree in position and one second in time.

At the University of Illinois Observatory, a special instrument has been designed for use by the faculty and students. Previous to this innovation, observations were made by catching one of the bright Sputniks on the crosshairs of an ordinary surveyor's transit and timing its passage with a stop watch. Directions could be measured to about two minutes of arc because of the accurate altitude and azimuth circles of the transit. After each such measurement, the lower plate of the transit was oriented by sighting on Polaris or on some other convenient star, and the stop watch was calibrated against WWV time signals.

But the transit telescope has a small aperture and restricted field, and it is so mounted that it cannot be pointed near the zenith. Therefore, at the suggestion of G. W. Swenson, an auxiliary wide-field rifle scope was attached, as shown in the picture. While the magnification is only 4x, the accuracy is the same as with the higher-power transit telescope because of the much greater ease in centering the image on the crosshairs, according to Dr. G. C. McVittie, director of the University of Illinois Observatory.

A different kind of observing instrument is needed to follow faint, distant, slow-moving satellites. Both larger aperture and higher magnification are essential at stations far outside the overhead latitude limits. From Cambridge, Massachusetts, for example, at latitude 42° north, Explorer I can pass only low in the sky at a great slant distance, since that satellite's orbital inclination is only 34 degrees. Consequently, it will always be a faint object, requiring great light-gathering power, but the angular uncertainty in its direction is somewhat lessened, so a smaller field of view can be used.



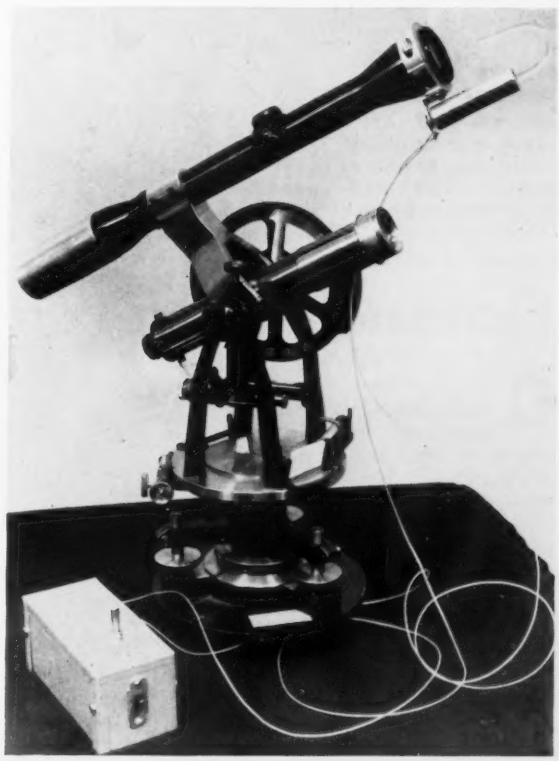
The MOONWATCH station at Cambridge, Massachusetts, is testing this modified M-17 elbow telescope, intended for tracking faint and distant satellites. Photograph by Robert E. Cox.

Pictured above is a new faint-satellite telescope now undergoing tests by the research group of the Cambridge MOONWATCH station. This is a modified U. S. Army M-17 elbow telescope, the original 50-millimeter objective being replaced by a 120-millimeter lens, according to a Naval Research Laboratory design. The optical system has an erecting prism, illuminated reticle, and an Erfle eyepiece providing a magnifying power of 20 with a 2.4-degree field of view.

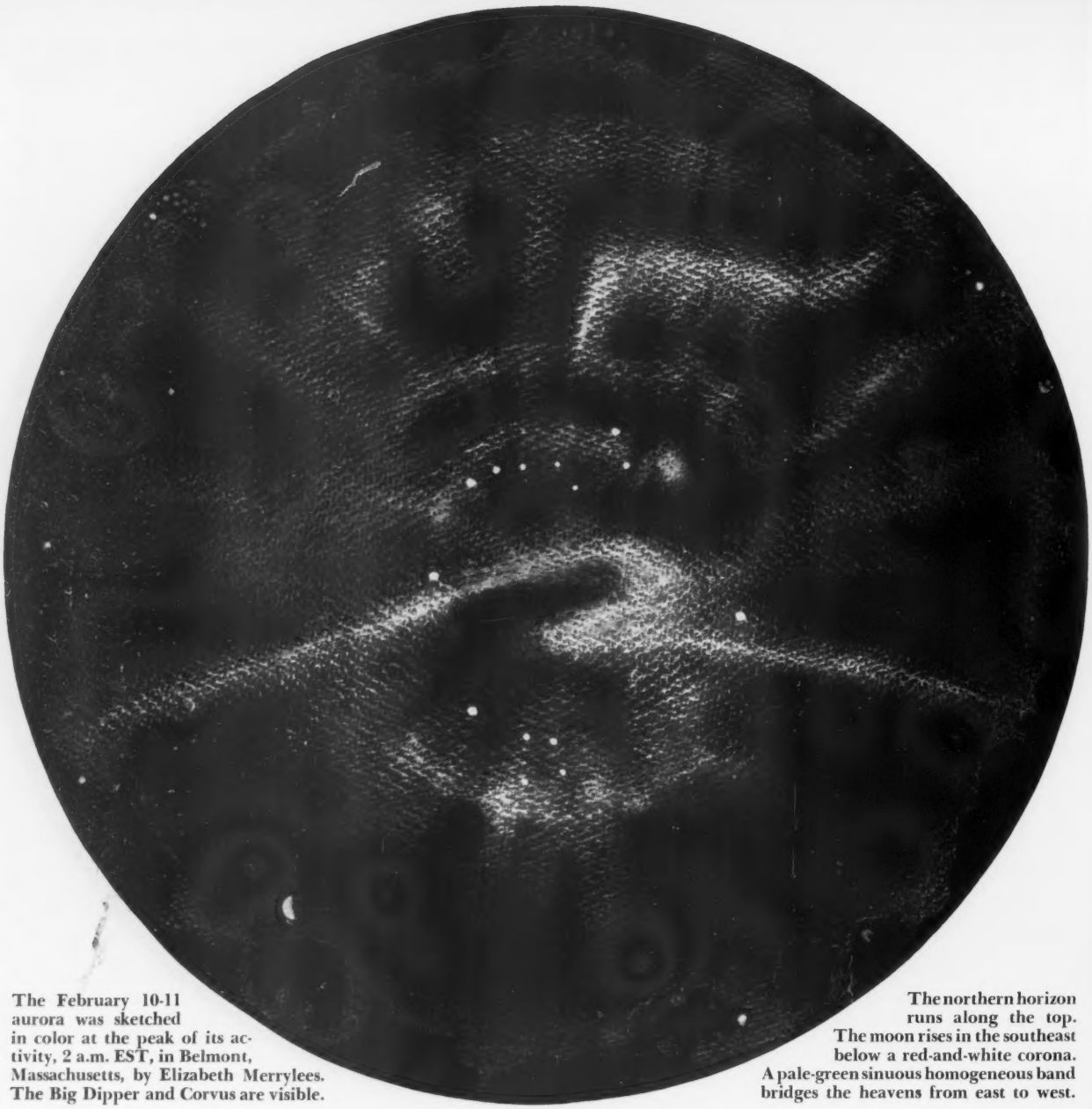
The mounting of this 20 x 120 telescope has been modified by the Cambridge group to permit rapid setting of altitude and azimuth. The photograph shows an altitude octant and a temporary azimuth scale, made by W. Russell Battersby.

Standard M-17 elbow telescopes are being used at the MOONWATCH station in Manhattan, Kansas. Walter Scott Houston tells of the advantages of these instruments in the November, 1957, issue of the *Great Plains Observer:* limiting magnitude close to 11 for stars, internal roof prism to provide a direct (not reversed) field of view, and illuminated crosshairs. From his experience in meteor observing, Mr. Houston believes that moving objects are apt to be overlooked unless they are at least two magnitudes brighter than the faintest stars visible. On this basis, a telescope that is to show an 8th-magnitude satellite must be able to show stars of magnitude 10.

Even slight dewing of the telescopes at Manhattan caused a two- or three-magnitude loss of light, so heaters were installed. First a layer of paper drafting tape was wrapped around the objective end of the telescope tube for insulation, then two turns of nichrome ribbon, and over this three layers of friction tape. A 5-volt a.c. current passes through the nichrome to provide enough heat to avoid the formation of dew, although the coil is barely warm to the touch. The 6-volt bulb for illuminating the reticle heats the eyepiece sufficiently to prevent its dewing.



At the University of Illinois, this modified surveyor's transit is used for bright satellites. A 4x Weaver K-4 rifle scope, with a 35-mm. objective, is attached to the main telescope axle by an easily removed bracket giving 2½ inches separation. The telescopes are made parallel by sighting them on the same bright star. An extension tube and diaphragm are added to the eyepiece to define the exit pupil (which has high eye relief). To illuminate the crosshairs, an aluminum capsule containing a small bulb and a lucite "light pipe" is mounted beside the objective. A rheostat on the battery box controls the crosshair illumination, which does not interfere with observations of bright satellites.



The February 10-11 aurora was sketched in color at the peak of its activity, 2 a.m. EST, in Belmont, Massachusetts, by Elizabeth Merrylees. The Big Dipper and Corvus are visible.

The northern horizon runs along the top. The moon rises in the southeast below a red-and-white corona. A pale-green sinuous homogeneous band bridges the heavens from east to west.

February's Great Multicolored Aurora

ONE of the finest auroral displays in years occurred on the night of February 10-11. Transparent skies over most of the United States and the absence of moonlight during evening hours helped bring out the beauty of the phenomenon. Especially remarkable were the unusual brightness, the strong red color contrasting with adjacent forms of green and white, and the formation of red coronas at the height of the spectacle.

The auroral storm made itself known in many ways. Long-distance telephone lines were affected by induced electric currents, disturbances of as much as 130 volts occurring. In the Boston area, two television channels unexpectedly swapped shows on the sets of viewers. In many places, the red skies caused false reports of large fires.

This display was seen in practically all parts of the country, even as far south as the Mexican border. At Tucson, Arizona, Don Strittmatter secured the accompanying photograph of saguaro cactus trunks silhouetted against the northern lights, and at midnight the aurora extended upward to the zenith. At Flagstaff, Lowell Observatory astronomers H. L. Giclas and W. M. Sinton also took pictures, and reported that maximum activity occurred about 11:30 p.m. MST.

In Florida, Miami residents were treated to a rare spectacle, and at Chapel Hill, North Carolina, Bill Baylis took pictures of homogeneous bands and rayed arcs from the roof of the Morehead Planetarium. He observed at about 9:30 p.m. Eastern standard time. Seventy miles away at Winston-Salem, Herbert G. Eidson, Jr., vice-chairman of the Forsyth Astronomical Society, captured the beauty of the aurora on daylight Kodachrome film. His 20-minute exposure with a Retina f/2.8 camera shows a strong green band along the northern horizon, with an enormous red area above it filling all the rest of the field of view. Several bright

star trails are recorded, while a nearby building and TV antenna appear in one part of the picture and give it depth.

In the Far West, observations were made for many hours. According to the Fresno *Bee* (sent by Mrs. Meta Rogers), the red glow was visible from the San Joaquin Valley in California most of the time between 6:50 and 11:40 p.m. Pacific standard time, and extended to the zenith. At Salem, Oregon, R. M. Bales had his first view at 7:20 p.m., although later he learned that the display had been seen as much as an hour earlier. He watched a bright cherry-red light in the northeastern sky grow to an altitude of 35 degrees; within 20 minutes the aurora had spread to the east, and white rays had formed.

At Greeley, Colorado, J. R. Otoupalik was able to see the red glow only for 10 minutes, at about 7:25 p.m. MST, through breaks in the clouds. Farther east, at Neodesha, Kansas, a fine red Kodachrome of bundles of rays was taken by James E. Watson. R. W. Crowder writes that he and Mr. Watson were listening to WWV time signals and noticed their broken tone due to the aurora, but did not look at the sky until some friends telephoned. At Topeka, Kansas, A. J. Morehouse took eight pictures between 10:30 and 11 p.m. Central standard time, using Tri-X film and an f/4.5 camera. He varied his exposures from 15 seconds to five minutes. His observing post was the Crane Observatory, Washburn University.

Two Iowa members of the Great Plains Astronomical Society reported their observations. At Des Moines, R. T. Morehead first noticed the aurora about 8 p.m. CST, when he casually glanced through a window. By 9:15 p.m., the northern sky was blood red, with a homogeneous arc about 50 degrees above the horizon. At Ft. Dodge, Mike Larson saw a brilliant rayed arc at about 8:05 p.m.; it was some 30 degrees high and fiery red. He watched until 2 o'clock in the morning, observing a coronal aurora at 12:25 a.m., vivid red mixed with white, and at 12:33 saw a flaming aurora, but not a strong one. Snow on the ground reflected dull red light during the display.

At Ft. Dodge, Iowa, Mike Larson took this photograph of the northern lights at 2 a.m. Central standard time. His exposure was 10 seconds at f/4.5 on Royal-X Pan film. The camera was pointed toward the northeast.

The earliest reported observation of the beginning of the event was made by Tim Hunter, at Arlington Heights, Illinois. He watched from 6:30 to 9 p.m. CST. The peak of the display was at 8:30, with a greenish white band extending clear across the sky, blotting out 2nd-magnitude stars as far south as Sirius. At the same time, a deep-red band stretched from 40 to 60 degrees high in the north, with strong rays every 20 degrees. Below the red was a bright greenish white area, covering the sky down to the northern horizon.

Mr. Hunter and Mrs. C. E. Fencken, at Hoopeston, Illinois, both saw bright auroral patches, which brightened quickly and faded within a few seconds. Mrs. Fencken noted a large red patch in the northwest at about 7:45 p.m. Other Illinois observations were made at Leland by Milton H. Scherger, who took photographs at 8:30 p.m.; at Urbana by members of the University of Illinois Astronomical Society, pictures being taken by Richard R. Steck; and at Danville by David Morrison. Just before 11:15 p.m., he photographed the western end of a bright southward-moving drapery that reached down to Sirius. He stopped observing at midnight, but checked the sky at 5:30 a.m. to find the display still strong.

Some Middle Western observers main-

Setting up his Speed Graphic camera in the Catalina foothills near Tucson, Arizona, Don Strittmatter obtained this picture of the February 10-11 aurora at 9:25 p.m. Mountain standard time. Tree-sized saguaro cacti stand starkly against the bright red glow of the northern sky.

Ray bundles of striking character, extending from low in the sky nearly to the magnetic zenith, were recorded by W. A. Feibelman at Pittsburgh.

tained all-night vigils. In Kentucky, Edward J. Pape, a member of the Louisville Junior Astronomical Society, watched for eight hours beginning at 8 p.m. CST. At Hammond, Indiana, Stanley Romanski recorded auroral changes from 9:30 p.m. to 5 a.m. He writes:

"At 10:45 almost due south, at an altitude of 50 degrees, there was a green band running east and west but disappearing in three minutes; then it reappeared a blood-red color, which also vanished in three minutes. At 10:50 a green color flared up to the southeast for three minutes, only to fade away and reappear as red, which similarly disappeared."

At Bellerose, New York, George Bauer, Jr., used a Super Ricohflex camera at f/3.5 to secure this auroral record at 11:27 p.m. EST on February 10th. The Verichrome Pan film was exposed for about 45 seconds.

Mr. Romanski observed two coronal auroras, one at 3 a.m. and the other at 5 a.m., the latter being green with dark red offshoots.

R. B. Larson, at Grand Rapids, Michigan, first noticed a red haze through clouds at about midnight. The sky cleared, and at 1:35 burst into the most spectacular display he had ever seen, with green draperies in the north as red and white rays reached down to the southern horizon. While driving along a highway, he found to his left that all the snow on the ground was red from the reflected glare of the aurora, and to his right everything was greenish white, from the light of the northern heavens. The whole sky and earth seemed to be on fire.

More reports came from L. V. Berry, Perrysville, Ohio, who described the display as the most beautiful in his experience; from Jerry Colgate, Salem, West Virginia, for whom the aurora lasted all night; and from David R. Kaiser, Eighty-four, Pennsylvania, who took a picture at 10 p.m.

Veteran aurora photographer W. A. Feibelman, Pittsburgh, Pennsylvania, was hampered by clouds until 10 p.m. EST. He writes:

"There was a great amount of red during the entire display, perhaps half the total light. At no time were any waves or flames seen here, and the over-all aspect was one of very slow changes, some forms being stationary for many minutes. Many red rays extended well beyond the zenith, and several coronas were observed, one at 11:15 in the southeast, with rays at the bottom being green, higher ones light red, and finally deep red at the apex."

After midnight the display faded, but by 3:45 a.m. it was again strong, reaching a maximum at 4 o'clock. During the night, the Pittsburgh observer obtained about 50 photographs, some in color; in addition, he took three long-exposure spectrograms with an auroral spectrograph he had constructed himself.

An early phase of the display, from 9 to 10 p.m. EST, was observed at Levittown, Pennsylvania, by Mrs. Wilson G. Ingraham, and when another peak was reached at about 2 a.m. her husband made a detailed photographic record. His pictures of the coronal aurora were among the finest received. Toward the west he photographed a rich blood-red

From the 83rd floor of the Empire State building, Nicholas Polowichak took this one-second exposure of a curtain-type aurora, mainly white but with red and green tints, at 1 a.m. EST, shortly after completing his duties as an associate television director for a New York station. Visible in the foreground is the top of the Chrysler building, with the lights of Queens and Flushing beyond it.

area, so bright that in a 30-second exposure the delicate ray structure was very much burned out. Color photographs were secured by R. E. Flory, at Princeton, New Jersey, who saw lavender patches in addition to red and green ones.

A striking auroral corona was observed by W. N. Gehrke at West Seneca, New York, about 3:35 a.m. A circular region of convergent rays, about 30 degrees across, was centered just south of the zenith, and had a dark center approximately two degrees in diameter. Within five minutes this circular region expanded and the central gap widened to break the northern side of the ring. Twenty minutes later the whole sky was aglow down to 20 degrees above the southern horizon.

Other New York State observers were William Webster of Islip Terrace, who sent drawings of the early evening phases; George Bauer, Jr., Bellerose, who took photographs at about 11:30 p.m.; J. Conte and P. DeVivo, Bayside, who observed from 9:15 to 10:30; and Nicholas Polowichak, New York City. Mr. Polowichak was working in the studio of WOR-TV on the 83rd floor of the Empire State building until 12:45 a.m., and noticed the aurora while turning off lights in the western part of the office, from which he could see shafts of light in the sky over New Jersey.

At Norwich, Connecticut, Dennis Downes observed from 9 to 11:15 p.m., and noticed that red and green alternated as the dominant colors. During the morning hours at Belmont, Massachusetts, Elizabeth C. Merrylees made the all-sky color drawing (on page 280 in black and white). The long homogeneous band that stretched entirely across the sky, on an east-west line, writhed at the zenith like a giant whip.

The climax of the February 10-11 auroral storm featured a bright coronal formation recorded here by Wilson G. Ingraham, Levittown, Pennsylvania. Using a Speed Graphic camera at f/4.7 and Royal Pan film, he secured this 30-second exposure at 2 a.m. EST. To the left are trails of the stars in Coma Berenices; the 1st-magnitude star Regulus and the Sickle of Leo are in the lower right.

One of the last observations that morning in New England was made by Paul H. Donaldson, Arlington, Massachusetts, at 5:20 a.m. EST, when he went outside to attempt photography of Satellite 1957β, only to find the sky bright with northern lights. Instead of a satellite record, he obtained the picture on the front cover of this issue. Meanwhile, at Lowell, Massachusetts, Walter L. Howe used his Stereo-Realist camera to obtain color pictures. At 5:25 a.m. there was red aurora in both the northwest and northeast parts of the sky.

These are all the reports received by *Sky and Telescope* before this issue went to press. This widely witnessed auroral display was a fitting accompaniment to the highest maximum ever recorded in the 11-year cycle of solar activity. There may be other great storms during the International Geophysical Year.

QUESTIONS... FROM THE S+T MAILBAG

Q. When naked-eye sunspots are reported, how can I see them without a telescope?

A. Sunlight shining into a darkened room through a fairly small hole will form an image of the sun on which such spots may be seen. Naked-eye sunspots are sometimes observed if the sun is dimmed by fog or by atmospheric absorption when it is near the horizon. Heavily smoked glass may be needed to protect the eyes on such occasions.

Q. How bright is the sun as seen from Uranus?

A. About apparent visual magnitude −20.4.

Q. Why are not artificial satellite positions predicted some months in advance?

A. Orbital changes from air resistance, especially for rocket-shaped satellites, are sufficiently unpredictable to make any extended ephemeris soon inaccurate. This matter is discussed on page 278 of this issue.

Q. What are the dashed lines on the Graphic Time Table of the Heavens for? (See *Sky and Telescope*, January, 1958.)

A. These lines give the times of events for an observer at the earth's equator.

Q. How do I calculate the magnifying power of a telescope?

A. Divide the focal length of the mirror (or objective lens) by the focal length of the eyepiece. For example, a telescope of 60 inches focal length with a ½-inch eyepiece gives a power of 120x.

Q. What is the latest estimated age of the universe?

A. The presently quoted values run about six to eight billion years, but current research may alter them considerably.

Q. What does it mean to say that a picture is taken in blue or red light?

A. It is in blue light when the photographic emulsion and filter combination records chiefly the blue region of the spectrum (wave lengths in the neighborhood of 4200 angstroms), and in red light if the region includes the hydrogen-alpha line at 6563 angstroms. W. E. S.

NEW COMET BURNHAM

(Continued from page 267)

ment Card 1401, and should facilitate detection of the comet with amateur telescopes. The right ascension and declination (1958 co-ordinates) are given for 0^h Universal time of every 10th day:

March 28, $6^h\ 54^m.0$, +22° 25′; April 7, $7^h\ 26^m.4$, +25° 26′; April 17, $8^h\ 04^m.4$, +27° 42′; April 27, $8^h\ 46^m.6$, +28° 54′.

CORRECTION

On page 227 of the March issue, near the top of column 3, Kepler's third law was misstated, for which the editors are responsible and not the author. The statement in the parentheses should read, "period squared is proportional to distance from the center cubed."

Irregularities in the Earth's Rotation — II

T. GOLD, *Harvard College Observatory*

THE ROTATION of the earth is not quite steady. Both the length of the day and the direction of the rotational axis are subject to certain changes, as told in last month's installment. The discussion is summarized in the table here, in which the different kinds of wobble and of speed changes are sorted out according to the time scale on which they occur.

There is just one section of this table that we have not yet dealt with, the one for axis wobble occurring in the very long times covered by the geological record. How much have the poles moved in geological times? Has there always been just a little wobble such as we know today, or has there been a steady drift over distances large enough to interchange polar and equatorial regions?

If these questions cannot be answered, then much of the geological record cannot be interpreted. Very large changes have taken place in the climates of different regions. Several areas now in warm climates were once under ice: India, parts of Africa, South America, and Australia. Over periods of 50 or 100 million years, many places seem to have changed their climate from one extreme to the other, from tropical to polar conditions, from desert to swamp.

These effects cannot be explained in the same way as the minor general climatic variations that account for the growth and shrinkage of the polar icecaps in the last million years or so. Clearly, no growth of the icecaps could account for the glaciation of India, if that country were where it is now, especially since we know that other areas were not glaciated at that time. But are we allowed to attribute these great glaciations of long ago, of regions now tropical, to a large drift of the earth relative to its rotational axis, bringing these regions successively to a pole?

CHANGES IN THE EARTH'S ROTATION

Time Span	Wobble of Axis		Length of Day	
Years	*Amount*	*Causes*	*Amount*	*Causes*
1	Up to 12 meters	Shifts of air masses.	0.001 second	Winds.
10	About 3 meters	Sea-level changes? Changes in core?	0.001 second	Changes in core.
1,000	(Unrecognized, but could be 300 meters)	.....	0.01 second	Sea-level changes. Tidal friction. Separation of materials inside earth.
10^9 (Geological times)	90 degrees	Shifts of masses on crust. Possibly interior changes.	Unknown	Gravitational sorting of material. Oceanic tides. Atmospheric tides.

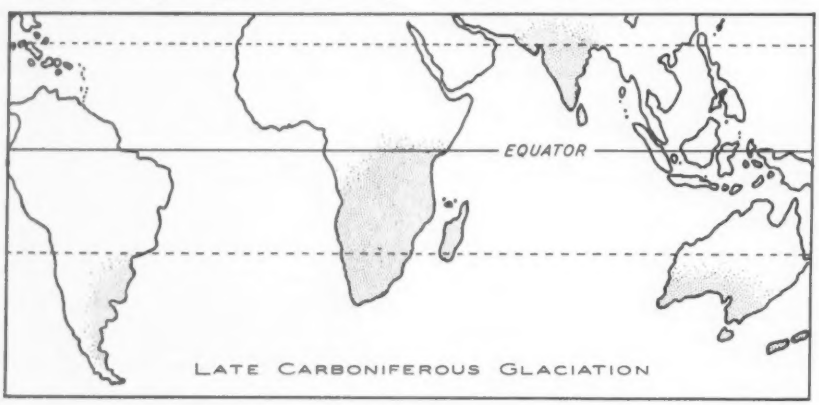
This question has been discussed from time to time by geophysicists, notably Sir George Darwin and Lord Kelvin. They considered it unlikely or impossible for any large change to have taken place. But we now recognize some faults in their arguments, and new knowledge concerning the structure of the earth has altered the picture. For this reason I came to disagree with their conclusions, and reopened the discussion in 1955.

Let me make it clear that there is no general physical law that prevents a body from turning over with the aid of *internal forces only*. The general law of the conservation of angular momentum merely prohibits a change of the value and direction in space of the body's angular momentum unless acted upon by an external force; but it has nothing to say about the orientation of the body relative to that direction. For instance, if a cat is dropped headfirst, it will contrive to land on its feet. Similarly, there is no fundamental difficulty connected with a large-angle polar movement, and we must merely see what disturbing internal forces have been available in geological periods and how big their effects are likely to have been.

If the earth were a sphere and not an oblate spheroid, then it would possess no stability at all against toppling over. A slight shift in mass would alter its orientation by a large angle. The actual stability of the earth is due to its spin, and to its equatorial bulge which gives it the property of a gyroscope. If the shape of the earth itself were unalterable, then this stability would be very great and all the upheavals of geology would have disturbed the axis by less than a degree. But is it reasonable to assume the earth is stiff enough to maintain its shape over long periods?

If it were that stiff, how does the earth happen to have the correct shape for its present speed of rotation? Why is the equatorial bulge not too big or too small? If the flattening at the poles were too small or too great, there would be a tendency for the oceans to concentrate in either the polar or equatorial regions, but this does not occur. Refined measurements tell us that almost exactly the right amount of bulging has occurred to make the globe's surface one of equilibrium. The present shape of the earth would not be the right one for a different speed of rotation. As we learned last month, however, the rotation may have altered drastically in the past. Therefore, we must suppose that the globe was later able to adjust itself to the proper shape, that is to say, it must be capable of a certain amount of plastic deformation.

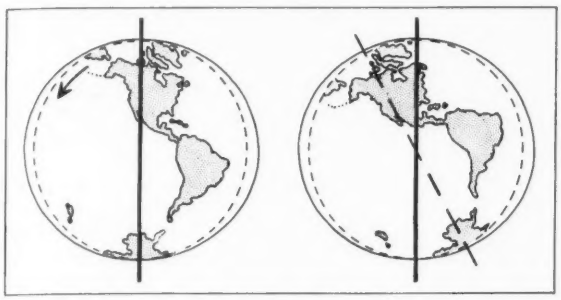
Of course, here we are concerned with the main shape of the earth, and must not be confused by the high degree of stiffness possessed by the very thin outer crust. The crust is under very different physical conditions from the interior, and it is no guide at all to the properties of the internal material. The crust's stiff-



During late Carboniferous times, some 200 million years ago, the dotted areas of South America, South Africa, India, and Australia, were covered by great ice sheets. The coastlines on this map are modern — not those of the Carboniferous period. Adapted from "Lectures on Rock Magnetism," by P. M. S. Blackett, published in Jerusalem in 1956.

ness is a very localized phenomenon — geological processes have succeeded in breaking up the crust almost everywhere, even folding and contorting it — and this broken outer crust does not even contribute to the stiffness of the whole body over long periods of time.

What, then, is the behavior of a spinning, bulging earth of such plasticity that it cannot indefinitely maintain a shape different from the equilibrium one? If on such an earth large masses were to move from one place to another, then the balance would be changed and the axis would immediately move by some small angle. But the earth now would be spinning around an axis for which it did not possess the precise equilibrium shape, and it would proceed to adjust its shape accordingly.

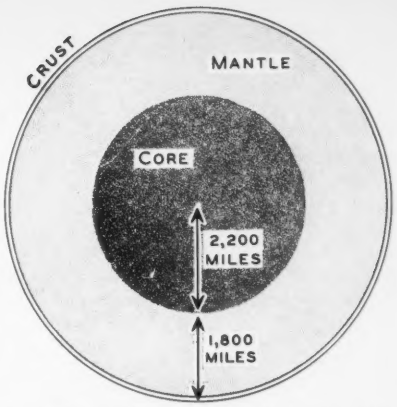


Left: If the earth topples over (arrow), its plastic body lets a new equatorial bulge form, maintaining the equilibrium shape. The rotation axis (solid line) keeps its orientation in space.

But it is only the original spheroidal shape that can prevent the globe from toppling over farther in the direction in which the unbalance is pulling it, so, as the shape adjusts itself, the toppling over proceeds. The process must then continue until the unbalance has disappeared, and this can only happen when the redistributed masses have changed significantly their relation to pole and equator. If, for instance, an extra mass had been placed at some intermediate latitude, the toppling over would have to proceed until this extra mass was located on the equator.

However, another well-known fact complicates the foregoing argument. The plasticity of the earth required to allow it to topple over would actually let the extra mass sink in, and the unbalance would therefore disappear. The big mountain chains, for example, are not surplus masses placed on a uniform earth. They are, in fact, regions where the material is a little less dense than average down to a depth of some tens of kilometers, and their equilibrium (floating) position therefore leaves them a little high. The mountains are in the same sort of equilibrium as pack ice is at sea. Geophysicists refer to this as *isostatic equilibrium*.

This isostatic adjustment means that, while we cannot consider the effect of an extra mass, we can still discuss the unbalance of the earth that results from the surface masses being of different densities and "floating" at different depths in the plastic material below. The center of gravity of each of these blocks could change its height as a result of, say, erosion or some process of mountain building, and this would produce an unbalance of the earth as a whole. For any given configuration of such floating blocks of crust, there would be one particular axis of rotation for which, after adjustment of the shape, the body could achieve a greater moment of inertia than for any other axis. The earth would then topple over gradually in such a direction as to make that the axis of rotation.



Right: The earth's interior, as revealed by earthquake studies.

It now remains to decide at what rate such a process might have been going on. Would it come within the geological time scale, or would it be much slower? Let us consider first the amount of unbalance and then the degree of plasticity of the earth's body.

There might be an unbalance arising from processes in the interior of the earth, but we do not have much information about that. Of the known processes, the most significant are undoubtedly the building of mountains, the ups and downs of continental blocks, and the erosion and probable growth of continents. A reasonably good estimate of the unbalance so produced can be made from geological data.

As for the plasticity, the present adjustment of shape to rotation speed indicates that the plasticity is enough to allow some adjustment in geological periods. However, the 14-month wobble of the earth, described last month, can give us a more definite value. With a perfectly elastic or perfectly stiff body, this component of the variation of latitude would have to be quite regular. If there were random exciting impulses, they would continue to build up the amplitude of the motion indefinitely. But, despite irregular disturbances, the motion remains small, proving the existence of some form of nonelastic dissipative behavior of the material. It is not farfetched to identify this nonelastic property, required for the damping of the 14-month wobble, with the plasticity that permits the earth to conform to the figure of rotation.

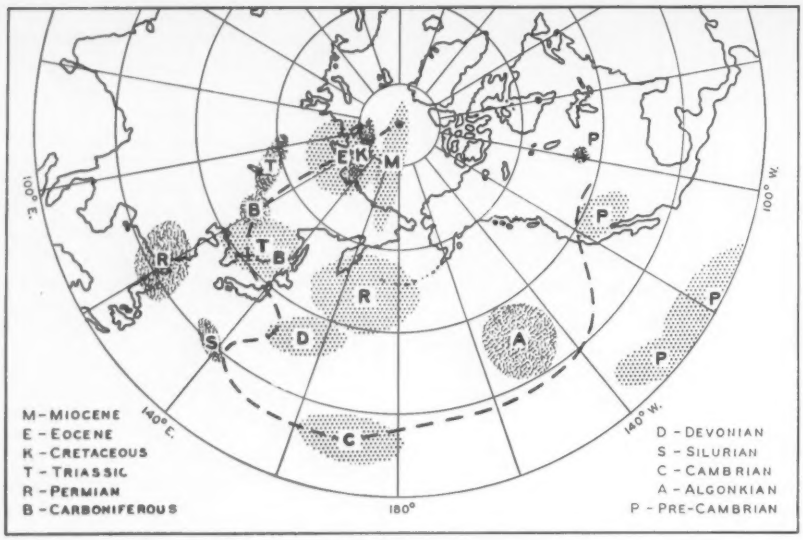
It can be shown that the nonelastic behavior must be resident in the main solid mantle of the earth (see diagram above), and not in its liquid core, as was thought at one time. Moreover, such plasticity is a common property of substances that are heated nearly to their melting points, and we think that much of the solid part of the earth is in this condition. From the degree of irregularity of the 14-month wobble, the plasticity can be evaluated. Then, by using the data concerning geological disturbances, an approximate value can be derived for the rate of possible polar movement.

Walter Munk's calculations confirmed my earlier work, and showed that a time between 10 and 100 million years would be required for the earth to turn over by a large angle, say 90 degrees. This is well within the geological time scale. Would a large polar drift therefore help explain the geological record?

Many geologists have favored a theory of continental drift, thinking that the main masses of the continents have shifted their relative positions by large amounts. Of course, there is nothing in the discussion about polar wander to suggest that continental drift has *not* taken place, although some of the arguments in favor of continental drift can be met by polar drift alone. There is other evidence, however, that seems to require both phenomena.

We can easily have polar wander with-

These schematic maps, after K. A. Pauly, show the drastic changes in climate produced by shifts in the pole position with respect to the continents (modern outlines). With the North Pole in the Pacific Ocean (see chart at top of page 286), Greenland and Scandinavia were in the tropics.



Migration of the north geographical pole since Pre-Cambrian time, after S. K. Runcorn. Dark ovals represent probable pole positions from North American rocks, dotted ovals from British. The dashed line is the inferred track of the pole.

out continental drift, but, except under the most artificial assumptions regarding the earth's interior, continental drift cannot occur without polar wander. The material under shifting continents would have to be so plastic that polar wander must certainly be expected as well.

Movement of the earth's outer crust as a whole, relative to the interior, has also been suggested as effectively moving the poles. This idea is a little like continental drift, except that all the surface moves together. Again, this is dynamically possible, but it requires a degree of interior plasticity that would itself allow a yet more rapid turning over of the entire earth by the processes already discussed. An interior so plastic that it would allow its skin to slip would itself have too little stability to resist turning over.

Will we ever know in detail what happened in the remote past? The geological evidence is suggestive but not sufficiently definite. However, in the last few years the answers have begun to come from a new technique — investigation of the magnetism of ancient rocks.

When lava pours from a volcano, it contains grains of iron-oxide minerals, and while these are still very hot their magnetism is easily aligned by the earth's weak magnetic field. In many rocks, once they have cooled, this orientation cannot be altered by a subsequent change in the earth's field. Thus, the magnetized particles act as tiny compass needles, preserving for future ages a record of the geomagnetic field at the time of the rock's formation.

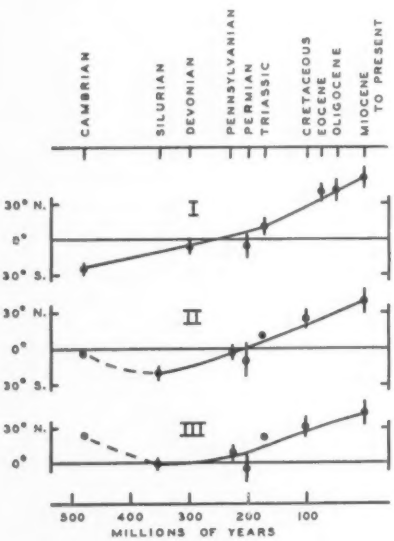
Another way in which some rocks may preserve their magnetism of long ago is by sedimentation. Magnetized particles are brought into alignment with the earth's field at the time of the deposition of the sediments.

These investigations have shown that in geologically recent times the average direction of the magnetic axis of the earth has coincided quite accurately with the rotational axis, even though at any one time there may be a considerable excursion. This provides a strong reason for supposing that the two axes always tend to go together over long periods. Therefore, analysis of numerous rock samples from one area and one period can give a good indication of the position of this area relative to the earth's rotational axis at that time. Different areas can be compared for the same period, to see whether or not they agree in specifying a particular position of the pole. If they agree, polar wander is indicated; if they do not, then areas of the crust must have moved relative to one another, providing evidence for the theory of continental drift.

Such data are being gathered at the present time, mainly by workers in Great Britain and Australia, and they have surveyed material from different epochs in the British Isles, America, Iceland, India, Australia, and other places. The evidence, when interpreted in the way we have discussed, is that polar wander has certainly taken place. There is no doubt that ancient rocks show very different directions of magnetization from recent ones, and such changes would seem to indicate that the North Pole must have moved in the last 500 million years from somewhere in the middle of the Pacific Ocean, by way of eastern Asia, to its present position. But there are some regions on the earth, especially in the Southern Hemisphere, where the direction of magnetization does not fit a simple polar movement, so substantial amounts of continental drift are also indicated.

These methods of paleomagnetism are very powerful, and many checks can be made for internal consistency of the data. In addition, geological information about climate is usually in good agreement with the magnetic data. Most likely, therefore, the earth has really been as unsteady a place as the magnetic record of the rocks would seem to show.

All this discussion started, last month, with the very precise measurement of very small effects. What I find so fascinating in this subject, however, is that the small effects are not measured merely to know something very precisely, but to learn about the very large effects that have taken place in the long history of the earth.



This chart from E. Irving shows variations of geomagnetic latitude for Great Britain (I), eastern United States (II) and western (III).

COMPARISON OF GEOMAGNETIC LATITUDES WITH ANCIENT CLIMATES*

	Eastern U. S. A. — Curve II		Western U. S. A. — Curve III	
Periods	*Latitude*	*Climatic indicators*	*Latitude*	*Climatic indicators*
Silurian to Mississippian	10° - 30°	Red beds, thick salt and gypsum deposits, coral limestones, dolomites	0° - 10°	Thick coral limestones, dolomites
Pennsylvanian and Permian	0° - 20°	Gray sediments, thick coals, types laid down in hot and humid climates	10° - 30°	Red beds with thick salt and gypsum deposits, large coral reefs
Triassic and Jurassic	10° - 30°	Red beds with salt deposits	10° - 30°	As above

*Taken from E. Irving, "Palaeomagnetic and Palaeoclimatological Aspects of Polar Wandering," *Geofisica Pura e Applicata, 33,* 23, Milan, 1956.

NEWS NOTES

FIRST PROGRESS REPORT OF IGY METEOR OBSERVING

A total of 18,885 meteors has been recorded in 8,743 10-minute periods up to October 15, 1957, according to the first progress report of the IGY Meteor Centre, National Research Council, Ottawa, Canada. The observations have been made by 371 individuals in 130 stations in Canada, the United States, Puerto Rico, Jamaica, England, and Switzerland. A number of reports from other countries, particularly Japan and Brazil, arrived too late to be included.

The report states that if the co-operating observers continue to remain active through the IGY period, it is certain that the data obtained, when combined with radar results, will give valuable information on the numbers and size distribution of meteoroids in the solar system.

The observations collected thus far are being analyzed by Dr. Peter M. Millman, of the National Research Council, and Miss M. S. Burland, of the Dominion Observatory. A bulletin is being planned to carry a list of observers, a summary of observing periods and meteors recorded, and other information.

Additional observers are invited to join the program, which was explained on pages 317-9 of the May, 1957, issue of *Sky and Telescope*. Observing forms and instructions may be secured from the Meteor Centre, IGY, National Research Council, Ottawa, Ontario, Canada.

A complete summary of station reports appeared in the February, 1958, issue of the *Journal* of the Royal Astronomical Society of Canada.

COLOR OF THE MILKY WAY

Some parts of our Milky Way, such as the Cygnus and Carina starclouds, are particularly rich in very luminous white stars of spectral types *O*, *B*, and *A*, characteristic of stellar Population I. On the other hand, the less luminous reddish stars typical of Population II are abundant toward the center of the system, in Sagittarius.

As a result of this, do various portions of the Milky Way show appreciably different colors to the naked eye? This question is asked by A. Pannekoek, retired director of the Astronomical Institute of Amsterdam University, in a letter in the December, 1957, issue of *Observatory*.

Dr. Pannekoek recalls that during his photometric survey of the Milky Way at Lembang Observatory in 1926 – long before the significance of stellar populations was realized – he noted the Milky Way in Sagittarius and Scutum appeared more yellowish or reddish than in Scorpius. On another occasion, the light in Cygnus appeared whiter than in Scutum.

He suggests that a study of possible color differences of this sort might be a useful project for an amateur astronomer with a sensitive eye and skies of excellent transparency. Since the southern sky contains the richest and most important parts of the Milky Way, the observations might be best made from South Africa, Australia, or western South America.

SUPERNOVA IN M83

A faint supernova that flashed up late last year in the spiral galaxy Messier 83 in Hydra has been discovered by H. S. Gates, of Mount Wilson and Palomar Observatories, during a comparison of films taken with the 18-inch Schmidt camera at Palomar.

The new object, which may be either a faint supernova or an unusually bright nova, is in a spiral arm of the galaxy, about three minutes of arc north-northeast of the nucleus. It is shown on films taken December 28, 1957, and January 16, 30, and February 14, 1958. On the last date the photographic magnitude was about 16.7. The discovery has been confirmed by E. F. Carpenter at Steward Observatory, Tucson, Arizona.

If Mr. Gates' find turns out to be a supernova rather than an ordinary nova, it will be the third detected so far in M83. The first was a 14th-magnitude star discovered by C. O. Lampland in 1923 at Lowell Observatory.

NEW LICK DIRECTOR

Albert E. Whitford will take over the directorship of Lick Observatory, Mt. Hamilton, California, on July 1st. He is succeeding C. Donald Shane, in charge since December, 1945, who is resigning from administrative duties to devote his full time to research.

Dr. Whitford is currently director of Washburn Observatory, University of Wisconsin. He is an internationally recognized authority on photoelectric photometry, both for his observations and for his improvements in photometer design.

FIVE STELLAR POPULATIONS

The current status of the study of stellar populations is reviewed by J. B. Oke, David Dunlap Observatory, in the February, 1958, issue of the *Journal* of the Royal Astronomical Society of Canada. In an article entitled, "Stellar Populations – the Key to Our Galaxy," Dr. Oke presents the accompanying table, to show how W. Baade's original two populations (I and II) have been revised and expanded into five groups, of different ages.

Population Group	*Age in Billions of Years*
Extreme Population I	0 - 1
Intermediate Population I	1 - 3
Disk Population	3 - 5
Intermediate Population II	5 - 6
Extreme Population II	6 - 6½

The list of examples in the table is only partial, but illustrates the content of the various populations. The percentages of heavy elements (those other than hydrogen and helium) are greater for the younger stars. This indicates that the latter are formed out of an interstellar medium that has a higher content of heavy elements than the original material from which the extreme Population II stars were made.

Dr. Oke concludes his article with a bird's-eye view of the role of the interstellar matter:

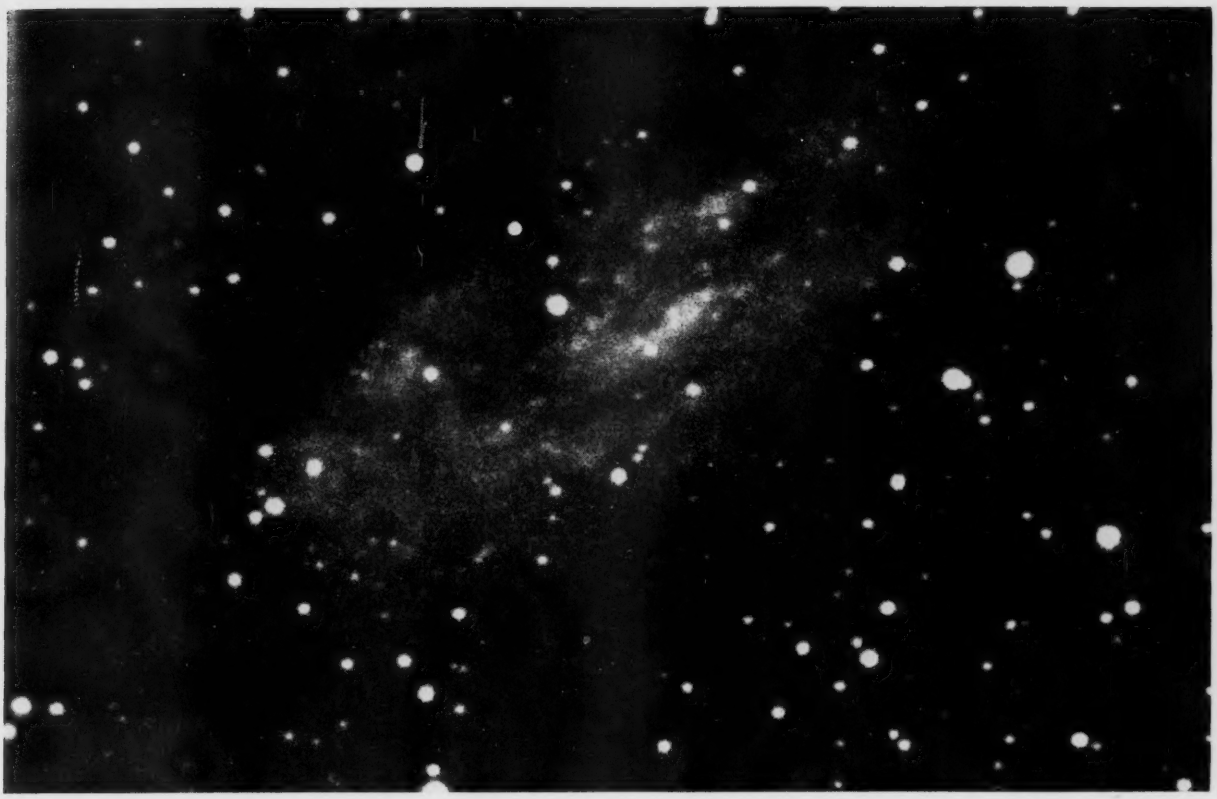
"When the first stars were born the galaxy must have been entirely interstellar gas. As each generation of stars formed out of this interstellar matter, some of the matter was trapped in the faint, almost unchanging stars of small mass. Thus after each generation there was less interstellar matter and more stars. At present only about 2 per cent of the mass of the galaxy is in the form of interstellar matter. Eventually this matter will almost completely disappear. When this happens, no new stars will form, very luminous stars will rapidly disappear, and we shall be left with a galaxy composed of faint, cool stars and tiny white dwarfs. Our Milky Way system will have become a rather uninteresting place in which to live."

Examples	*Heavy Elements*
Hot *O*- and *B*-type stars Interstellar gas and dust Young galactic clusters	4 %
Older galactic clusters	3 %
The sun	2 %
"High-velocity" stars	1 %
Globular clusters in the galactic halo	0.3%

IN THE CURRENT JOURNALS

GALAXIES AND THEIR STELLAR POPULATION, by Walter Baade, *Observatory*, October, 1957. "There must have been a period of star formation in all galaxies at about 6×10^9 years ago. In slowly rotating systems all the dust and gas condensed into stars at that time. In the more rapidly rotating spirals most stars were formed at that early epoch but some dust and gas remained and has enabled some star formation to continue."

ANCIENT TEMPERATURES, Cesare Emiliani, *Scientific American*, February, 1958. "The ratio of the oxygen isotopes in a fossil shell reflects the temperature of the water in which the shell grew. This 'thermometer' is now used to study the climate of the past."



The field of the spiral NGC 2427 is rich in stars of the Milky Way. This is a one-hour exposure without a filter on an Eastman 103a-O plate, made October 23, 1954, with the Radcliffe Observatory 74-inch reflector. The reproduction has north at the top and a scale of 2.9 seconds of arc per millimeter.

Among Southern Galaxies—III

RESOLVING POWER increases with the aperture of a telescope. This month's full-page picture of a southern galaxy, NGC 300, was taken with the 74-inch Radcliffe Observatory reflector. It shows many more stars and finer details in the spiral arms than does the photograph with the Mt. Stromlo 30-inch reflector published in *Sky and Telescope* for September, 1957, page 521.

Here the galaxy is well resolved into stars of magnitude 17 and fainter, and there are many somewhat brighter knots of emission nebulosity involved in it. Numerous star clusters containing luminous blue giant stars mark the spiral arms of this very late-type spiral, and there are low-contrast dark lanes of obscuring dust.

Like NGC 253 pictured last month, NGC 300 is a member of the Sculptor grouping of bright galaxies near the south galactic pole of the sky. It is in many respects analogous to the familiar northern system, Messier 33 in Triangulum, but NGC 300 bears the earmarks of even later type, having a lower surface brightness. It shows a very small nucleus, and the arms are well opened and broken up loosely into starclouds.

The total magnitude of this system is photographically about 8.5, but different investigators assign very discordant values. According to G. de Vaucouleurs, the brighter inner portion of NGC 300 measures 18 by 12 minutes of arc, but the fainter outlying parts can be traced over 22 by 16½ minutes. It is located at right ascension $0^h\ 52^m.6$, declination $-37°\ 58'$ (1950 co-ordinates), and its velocity of recession is about 200 kilometers per second. The distance of NGC 300 is uncertain, but has recently been estimated by Dr. de Vaucouleurs as perhaps two million parsecs. He has classified the galaxy as type SA(s)d in his new system (page 582, October, 1957, issue).

Three years ago an Australian radio astronomer, B. Y. Mills, reported that NGC 300 is a radio source, from observations made with the 1,500-foot interferometer of the Radiophysics Laboratory at Sydney.

The galaxy pictured at the top of this page is NGC 2427, another very late-type southern spiral. Even though, like NGC 300, it was discovered by Sir John Herschel more than 120 years ago, very little is known concerning it today. One of the reasons for this is that NGC 2427 is situated in Puppis, only 12 degrees from the galactic equator, where it is dimmed by interstellar dust within the Milky Way system. Its position is $7^h\ 35^m.1$, $-47°\ 30'$ (1950).

Of about total magnitude 10, NGC 2427 is not resolved, except for a few knots which may be gaseous nebulae, and the extreme dimensions are 6.0 by 2.4 minutes, according to Dr. de Vaucouleurs. The spiral structure is strongly asymmetric, which is characteristic of late-type systems intermediate between normal and barred spirals. The de Vaucouleurs classification is SAB(s)dm.

FACING PICTURE: Covering a sky area about one-half that of the moon, NGC 300 is one of the largest spiral galaxies. This 30-minute exposure with the 74-inch Radcliffe Observatory reflector was made on November 14-15, 1950, using Eastman 103a-O emulsion without a color filter. The reproduction scale is 5.1 seconds of arc per millimeter. This series of southern-galaxy pictures began in the February, 1958, issue. They are being published with the permission of R. H. Stoy, Her Majesty's Astronomer at the Royal Cape Observatory, Cape of Good Hope, South Africa.

ASTRONOMICAL SCRAPBOOK

JULIUS SCHMIDT AND THE MOON

ANYONE interested in literature about the moon will soon come across the name of J. F. Julius Schmidt (1825-1884), famed for his great lunar atlas, his measurements of mountain heights, and his discoveries of rills and other detail. There is seldom a full-dress controversy among amateur observers of the moon in which his name is not called upon by one side or the other.

Although Schmidt was director of Athens Observatory for a quarter century and a trained professional, amateur astronomers might well claim him as one of their own. Singlehanded he carried out a program resembling in scope and volume the combined efforts of the British Astronomical Association's present-day observing sections.

Perhaps Schmidt's energy as an observer has never been equaled. For example, variable stars were a favorite subject of his for four decades. During the last two years of his life he made no fewer than 85,000 observations of variables. His record books contain 9,800 brightness estimates of Delta Cephei and 5,800 of Beta Lyrae. Many of the more familiar naked-eye variable stars were discovered by him, including Eta Geminorum, Rho Persei, u Herculis, and Delta Librae.

As a planetary observer Schmidt showed equal enthusiasm. His great series of over 780 drawings of Jupiter provided the material for a later German's doctoral dissertation. At a single opposition of this planet, Schmidt timed 98 central meridian transits of the great red spot, a record never again approached. His sunspot observations were so numerous as to be reported in book form; meteors, the zodiacal light, nebulae, lunar eclipses, and comets were also observed on the same extensive scale. But the special love of this unwearying man was the moon.

As a 14-year-old boy in his native town of Eutin in north Germany, Schmidt bought at an auction a copy of Schröter's famous book on the moon. His imagination was fired by the many pictures of lunar craters and mountains, and his one desire was to explore these wonders for himself. A small refractor with lenses ground by his father became Schmidt's first telescope, and with this he began making drawings of the moon. Having very acute vision and great skill in sketching, he realized that his efforts would become of scientific value as soon as he could use more powerful instruments.

This opportunity arrived in July, 1841, when Schmidt moved to Hamburg, and was allowed regular use of the telescopes at the observatory there. In 1845 he got a position at the private observatory of J. F. Benzenberg at Bilk, near Düsseldorf. This proved a disappointing experience; the large refractor was reserved by Benzenberg for his own searchings after an intramercurial planet, and when not in use by him was kept under lock and key. For Schmidt there was only a small telescope, with an objective too defective for any serious lunar work.

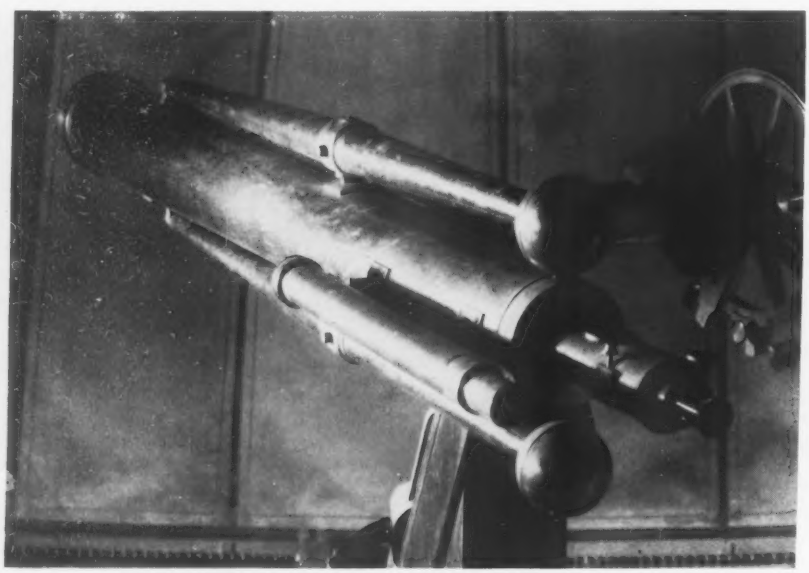
A few months of this was enough, and Schmidt went to Bonn Observatory to spend eight years as F. W. A. Argelander's assistant. Here there was opportunity to continue the lunar drawings, in the intervals not filled by routine meridian-circle work, or by the zone observations of stars for the great *Bonner Durchmusterung*. On several visits to Berlin, he had the use of the Royal Observatory's 9-inch refractor — the same instrument with which J. G. Galle first recognized the planet Neptune. Schmidt tells how on May 17, 1853, this telescope showed him no fewer than 78 craters on the floor of the ring plain Clavius.

J. F. Julius Schmidt, from a photograph taken December 16, 1882.

About this time, Schmidt was invited on Argelander's recommendation to take charge of the private observatory of E. von Unkrechtsberg, at Olmütz in Moravia. Here there was freedom from routine, and a Fraunhofer refractor of 5-foot focal length, with a good filar micrometer. This equipment was at once put to use for the measurement of lunar mountain heights from the lengths of their shadows. In the next three years Schmidt made almost 3,000 height determinations; even today these measurements are still our main source of information about relative elevations on the moon.

During his stay at Olmütz, he wrote *Der Mond*, a useful 164-page treatise on selenography, published at Leipzig in 1856. It is perhaps the first discussion of the lunar surface by anyone well versed in geology.

Schmidt's last move was to Greece, where he assumed the directorship of Athens Observatory in 1858. (The previous director, G. K. Bouris, once aroused an angry clamor by proposing that famous buildings of the ancient city be demolished to give the observatory a clear southern horizon.) Under the favorable Greek sky, the German astronomer resumed his detail drawings of the moon with renewed vigor. By 1865 their num-



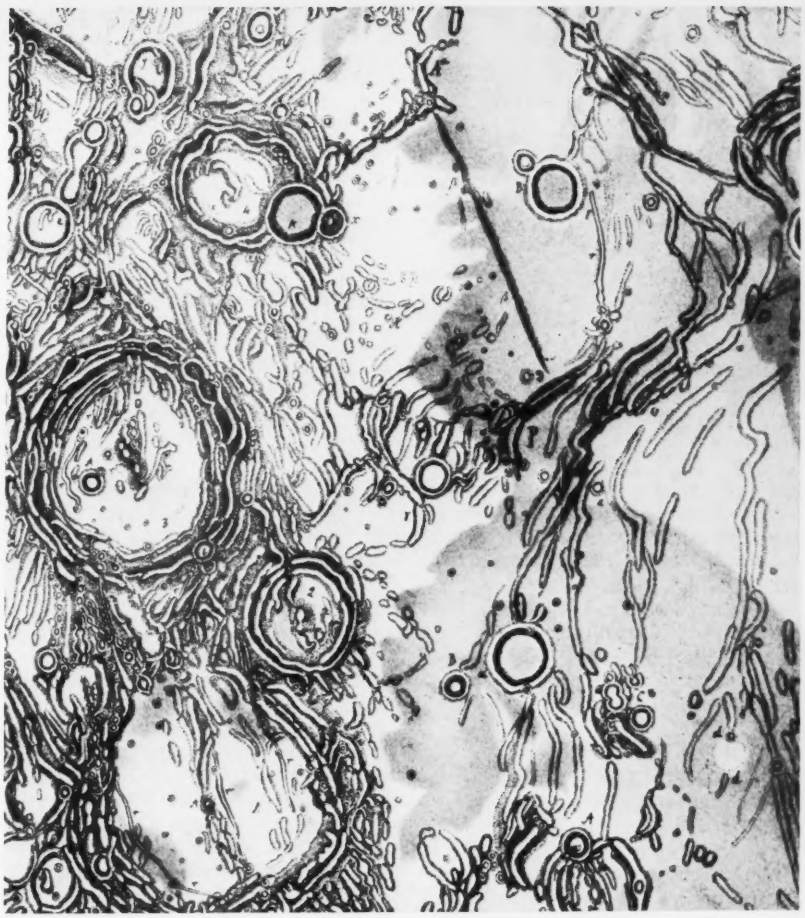
The 6.2-inch short-focus Ploessl refractor of Athens Observatory, used by Schmidt. "In good seeing," he wrote, "I generally employed a 300x eyepiece for drawing the moon, very rarely 500x to 600x." Both photographs on this page are courtesy of Prof. S. Plakidis, University of Athens.

ber was so great that he began to compile from them a general topographic map of the moon, which was corrected and added to by new telescopic observations.

In its final form, this map consists of 25 sections, which in combination show a lunar disk six feet in diameter. Some of the sections are based on 150 drawings, gathered over three decades. In all, 32,856 craters are represented; Schmidt estimated that a complete survey with the 6.2-inch Athens refractor at 600x would reveal 100,000 craters. This chart greatly surpassed in completeness and accuracy anything previously attempted. One indication of its continuing value is that during the past year or two inexpensive reproductions of it have been published in England and the United States.*

The atlas was published at Berlin in 1878 as *Charte der Gebirge des Mondes* (*Map of the Mountains of the Moon*). Simultaneously, a companion text appeared under an identical title, except for the addition of the word *Erläuterungsband* (*Explanatory Volume*). This is still an invaluable source book, containing, for instance, the full details of all Schmidt's height measurements, catalogues of rills and ray systems, and a wealth of descriptive notes. (E. Neison's often-quoted *The Moon* came out in 1876, too early to use Schmidt as a source.)

*Schmidt's map is available in reduced-scale reproduction for $1.75 from Scientific Book Service, 663 Franklin Ave., Columbus 15, Ohio.



Part of Sheet 8 of Schmidt's lunar atlas, reproduced at about two-thirds original scale, with the moon's central meridian running along the western (left) edge. The Straight Wall is in upper center. Schmidt marked craters with numbers: Alphonsus (lower left) 1, Alpetragius 2, Arzachel 3, Thebit 4.

The neighborhood of Tycho under a setting sun is shown in the frontispiece to "Der Mond," Leipzig, 1856. Young Schmidt made this drawing on September 17, 1843, at the Hamburg Observatory. The very large ring near the top is Clavius; Tycho, half-filled with shadow and with a central peak, is near bottom center. Schmidt says he did not have time to insert all of the fine detail then visible.

Of special importance is the section on Linne, the most famous case of probable lunar change. This is the formation in Mare Serenitatis that up to the year 1843 was generally recorded as a small, deep crater; in October, 1866, Schmidt reobserved it as a white spot — its usual appearance to the present day. On pages 155 to 163 of his book, Schmidt reports individually his 200 observations of Linne from 1841 to 1874 — basic data for any serious attempt to solve the mystery. He remarks that several other lunar features, such as Werner D and Lassell D (Alpetragius d), seem exactly analogous to Linne, each of them appearing as a bright patch containing a minute crater pit. In the chart above, Lassell D is the light area "dd" in the lower right corner.

Schmidt's atlas and accompanying volume of text incorporate his lunar observations only to the year 1874, but his selenographic studies continued until his sudden death on February 7, 1884. During this decade, according to his official Athens Observatory reports, he made 2,536 more lunar drawings, a larger number than he had used for the atlas. So far as I know, this additional work on the moon has never been published in any form, or even analyzed, although it would be a rich mine for study.

Does anyone know the present whereabouts of Schmidt's manuscripts for that period? When publication of the atlas was undertaken by the Prussian ministry of education in 1875, it acquired by purchase the rights to the work; the original atlas remained in Berlin while Schmidt was given photographic copies. Did this arrangement mean that title to Schmidt's lunar observing records also passed to the government, and thus did the papers for 1875-84 possibly go to Berlin?

Some of Schmidt's records, such as the larger part of his variable star journals, were deposited at the Potsdam Observatory. Perhaps the unpublished lunar observations accompanied them. This possibility is suggested in the history of the Athens Observatory by D. Eginitis. It would be of considerable value to students of the moon if this long-lost material could be located for analysis and possible publication.

JOSEPH ASHBROOK

Amateur Astronomers

ASTRONOMICAL LEAGUE TO MEET AT ITHACA

Cornell University in Ithaca, New York, will be the site of the 12th general convention of the Astronomical League on July 3-6. The Astronomy Section of the Rochester Academy of Science will be cohost with the university.

The tentative program includes sessions on satellite tracking and observing, instrumentation, and observational astronomy, as well as sessions for juniors and the Association of Lunar and Planetary Observers. Program time may be secured by sending an abstract promptly to George T. Keene, 76 Westland Ave., Rochester 18, N. Y. Talks should be limited to 20 minutes.

Ample space will be provided for the display of exhibits. Arrangements may be made with Edwin M. Root, 143 Branford Rd., Rochester 18, N. Y.

Two star parties are scheduled at the Fuertes Observatory during the meetings. The Northeast Region of the league will also hold its annual business meeting on the final day of the general convention.

MORE JUNIOR GROUPS

At Rockford, Illinois, 35 members who are mostly teen-agers comprise the recently formed Rockford Astronomical Society. Officers are Ric Mayes, president; Mike Meeker, vice-president; and Barry Doan, treasurer. The secretary is William Fonvielle, 528 Howard Ave., Rockford, Ill.

Twelve juniors have organized the Crescent City Celestial Society in New Orleans, Louisiana. Further information may be secured from Harris H. Yates, 5600 Elysian Fields Ave., New Orleans, La.

Two Texas clubs have also been started for juniors, the Waco Junior Astronomical Society and the Plainview Amateur Astronomical Society. The former may be contacted by writing Donny A. Chandler, 3709 Trice Ave., Waco, Tex.; the latter, Gary Hall, 506 Travis St., Plainview, Tex.

SOLAR SYSTEM TO SCALE

Larry Minego, of the Tampa Amateur Astronomical Society in Florida, has compiled some figures that indicate the vast size of the solar system. He visualizes a model in which a tiny 1/16-inch sphere would represent the smallest natural satellite known.

This is Deimos, the second moon of Mars, about five miles in diameter, and it sets the scale of the model at one inch equal to 80 miles. The earth becomes a sphere just under 8½ feet in diameter, while the sun is so large that three football fields can be placed end to end within it.

From the sun out to the orbit of Pluto would be about 725 miles. Thus, the entire solar system would just fit into Brazil, if such a model could be constructed!

NORTH CENTRAL CONVENTION

The 1958 convention of the North Central Region of the Astronomical League will be held at Milwaukee, Wisconsin, on Saturday, May 17th, with the Milwaukee Astronomical Society as host. The meeting will be at the new YMCA building, 9th and Wisconsin Ave. Early arrivals are invited to the Milwaukee club's meeting on the previous evening at the Public Museum.

The registration fee, $1.00 until May 1st, may be sent to Richard R. Fink, Apt. 402, 3553 N. Oakland, Milwaukee 11, Wisc. He will also accept banquet reservations at $2.25 per person.

CARL H. GAMBLE DIES

The founder and president of the Popular Astronomy Club, Carl H. Gamble, passed away on January 25th. The Moline, Illinois, society was organized in 1936, and five years later Mr. Gamble built his own Sky Ridge Observatory, "to provide facilities for the people of the community to learn about astronomy." The observatory was the meeting place of the club, and was opened to the public on many occasions for star parties. It is also the site of a MOONWATCH station.

After his retirement from the John Deere Spreader Works in 1947, the Illinois amateur devoted most of his time to astronomy. He gave more than a thousand talks to an estimated 75,000 people. In 1951 he received an honorary doctoral degree from Augustana College.

Mr. Gamble willed the entire observatory, including its 5½-inch Zeiss refractor, to the college, which is making plans to relocate it near the campus in Rock Island, Illinois. It is possible that a small planetarium may be built there as well.

UTICA, NEW YORK

The Utica Amateur Astronomers are in the final stages of grinding the mirror for a 10-inch Cassegrainian reflector, which they expect to finish in early summer. Another group project is the construction of a small radio telescope, which is partially completed. The group used this instrument to pick up the radio signals from the first American satellite, about two hours after the Explorer's launching at Cape Canaveral in Florida.

New officers for the society are Stanley Wolczanski, president; Richard L. Carver, vice-president; and Walter Burak, Sr., secretary-treasurer.

MEMPHIS, TENNESSEE

The Memphis Astronomical Society was organized in March, 1953, its original purpose being to provide a planetarium for the Memphis Museum. Through the group's efforts the city park commission allocated $5,000 for the installation, which has since been regularly serving the public. The society has 50 members, about half of whom are juniors.

The January 3rd meeting drew an audience of 100 to a demonstration of static electricity. Many of the telescopes used by the club have been made by the members, including an 8-inch reflector. Another project is providing lecturers for clubs, schools, and boy scouts. George P. Turner, 3713 Wilshire Rd., Memphis, Tenn., is the society secretary.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. Apr. 3, Charles A. Federer, Jr., "How To Learn the Constellations."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Apr. 18, Dr. Thomas Gold, Harvard Observatory, "The Large-scale Structure of the Universe."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Dallas Health Museum Planetarium. Apr. 28, R. W. Olson, "Four if by Space."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., Geneva City Hall. Apr. 15, William Siekman, Jr., "A Near Star."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Apr. 9, Richard R. Fink, "The Milwaukee Astronomical Society and the Regional Convention."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Apr. 2, Dr. John P. Hagen, Project Vanguard, "Man-made Moons."

Plainfield, N. J.: Amateur Astronomers of Union County, 8 p.m., Stillman School auditorium. Apr. 18, "What You Can Do as an Amateur Astronomer."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Apr. 5, Dr. Alfred H. Mikesell, U. S. Naval Observatory, "Scintillation, Seeing and Site-Testing."

PATERSON, NEW JERSEY

The color motion picture, Our Mr. Sun, will be shown at the April 3rd meeting of the North Jersey Astronomical Society. There is a possibility the presentation will be at the local high school; further information should be obtained from Donald Trombino, 4-4D Alabama Ave., Paterson 3, N. J.

TORONTO, CANADA

The telescope makers section of the Royal Astronomical Society of Canada presently has about 80 members. Several are working on mirrors from three to 12½ inches in diameter, with the 6-inch f/8 size most popular.

In the section's workroom there are six grinding stands, a work table, and two testing benches. The group meets on alternate Fridays at 8 p.m., at 252 College Ave., Toronto, Canada. Jesse Ketchum is director.

HERE AND THERE WITH AMATEURS

Most of these societies hold regular meetings once or twice monthly, at which interested persons are always welcome. Details of each society's program can be obtained from the official whose name and address are given here.

*Members receive *Sky and Telescope* as a privilege of membership.
†Member organization of the Astronomical League.
‡Member organization of the Western Amateur Astronomers.
°Society has junior section.
‖Independent junior society.

ALABAMA

BIRMINGHAM
Shades Valley Astronomy Club *
Mrs. I. M. Cox, 208 Dexter Ave. (9). TR 1-1639

HUNTSVILLE
Rocket City Astronomical Ass'n. *†
G. A. Ferrell, 621 Franklin St. JE 4-4809

ARIZONA

PHOENIX
Phoenix Observatory Ass'n. *‡
A. H. Hoff, Phoenix College. AM 6-4441

TUCSON
Tucson Amateur Astronomers *
E. Sydow, 3025 E. Eastland.

ARKANSAS

AUGUSTA
Augusta Astronomy Club *†‖
J. W. Haralson, Box 634. Augusta 35

LITTLE ROCK
Arkansas Amateur Astronomy Club *†
J. Adams, 2216 State St. FR 2-6801

CALIFORNIA

BAKERSFIELD
Kern Astronomical Society, Inc.
R. Stephens, 1230 Washington Ave., Oildale. EX 9-6587

EUREKA
Astronomers of Humboldt
W. N. Abbay, Jr., 1745 Margaret Lane, Arcata. VA 2-4403

FRESNO
Central Valley Astronomers *‡
G. Reavis, 626 W. Lamona. AM 4-9771

LAGUNA BEACH
Laguna Beach Astronomy Club
Miss E. Phillips, 370 Anita St.

LONG BEACH
Excelsior Telescope Club *†‡
T. R. Cave, Jr., 265 Roswell Ave. HE 4-2263

LOS ANGELES
Los Angeles Astronomical Society, Inc. ‡
Miss L. Carlson, 3047 Vista St., Long Beach.

OAKLAND
Eastbay Astronomical Society, Inc. *‡
Miss P. Metz, 4827 Brookdale Ave. (19). KE 6-2074

OROVILLE
Feather River Astronomy Club
J. T. Jensen, Rte. 4, Box 1732. LE 3-0471

PALO ALTO
Peninsula Astronomical Society *‡
Miss A. Alksne, 4115 Amaranta Ave. DA 2-4406

PLEASANT HILL
Mount Diablo Astronomical Society
D. F. Charles, 868 Audrey Court.

REDLANDS
Redlands Astronomical Society *
Mrs. E. Patterson, 2698 Fremontia Dr., San Bernardino. 83-7238

RIVERSIDE
Riverside Astronomical Club
B. F. Jones, 5551 Magnolia Ave. OV 3-1854

SACRAMENTO
Sacramento Valley Astronomical Society *‡
Mrs. H. Smith, 1608 48th St. (19). GL 1-1483

SAN FRANCISCO
San Francisco Amateur Astronomers *‡
H. Sturiale, 1349 Clayton St. UN 3-3808

SAN JOSE
San Jose Amateur Astronomers *‡
W. W. Phelps, 21090 Hazelbrook Dr., Cupertino. CH 3-1649

SAN RAFAEL
Marin Astronomical Society *‡
J. P. Treleven, Box 102, Fairfax.

SANTA ANA
Orange County Amateur Astronomers *
G. H. Shaw, 2061 Halladay St. KI 3-9131

SANTA BARBARA
Santa Barbara Star Cluster ‡
Capt. C. Adair, 607 Miramonte Dr. 2-1717

STOCKTON
Stockton Astronomical Society *‡
C. E. Spurgeon, 1429 S. Lincoln St.

WHITTIER
Whittier Amateur Astronomers Ass'n. *‡
G. E. Hughes, Box 531. OX 4-2840
Whittier Astronomical Society *†
R. N. Sturtridge, 8416 Davista Dr.

COLORADO

BOULDER
Boulder Astronomical Society *†
V. A. Ryan, 1629 North St. HI 2-6223

COLORADO SPRINGS
Colorado Springs Astronomical Society *
R. C. Moore, 2427 Paseo Rd. ME 3-7181

DENVER
Denver Astronomical Society *†°
E. H. Bronstein, 1747 S. Jasmine (22). SK 6-3232

PUEBLO
Pueblo Astronomical Society *†‡
Mrs. M. Struthers, 2329 E. Routt Ave. LI 3-1833
Pueblo Junior Astronomical Society †‖
H. Niethammer, 839 Van Buren. LI 4-2819

CONNECTICUT

MIDDLETOWN
Central Connecticut Amateur Astronomers *†
W. Fellows, R.F.D. 1, Hebron Ave., Glastonbury. ME 3-1871

NEW HAVEN
New Haven Astronomical Society, Inc. †
Mrs. J. Plato, 427 Ridgeview Rd., Orange. SY 9-2524

NEW LONDON
Thames Amateur Astronomical Society *†
Mrs. R. W. Tumicki, R.F.D. 1, Box 497, Uncasville. TI 4-8336

STAMFORD
Fairfield County Astronomical Society *†
D. Mitchell, Cliffdale Rd., Greenwich. TO 9-1684

STRATFORD
Boothe Memorial Astronomical Society, Inc. *†
B. W. Reilly, Box 2272, Noble Sta., Bridgeport (8). ED 6-9287

TORRINGTON
Litchfield Hills Amateur Astronomy Club
Miss G. Weaver, 37 James St. HU 9-8168

DELAWARE

NEWARK
Delaware Astronomical Society *†
R. J. Van Caneghem, 11 Kullen Dr., Brookside. EN 8-6024

DISTRICT OF COLUMBIA

WASHINGTON
National Capital Astronomers *‡°
Miss P. Seips, Box 271 (4).

FLORIDA

DAYTONA BEACH
Daytona Beach Star Gazers
W. T. Thomas, 105 N. Halifax. CL 2-8049

EAU GALLIE
Indian River Astronomical Society *†
Mrs. H. M. De Paolo, 1353 Everglade Dr. 3213

FT. LAUDERDALE
Ft. Lauderdale Astronomical Society †
Dr. F. Denniston, 915 N. E. 2nd St. JA 2-5224

JACKSONVILLE
Jacksonville Amateur Astronomers Club *†°
E. L. Rowland, Jr., 225 W. Ashley St. EL 4-8597

LAKELAND
Lakeland Astronics Society *
W. Scholl, 67 Fla. Southern Coll. MU 3-8475

KEY WEST
Key West Astronomy Club *†
Miss M. W. Turner, 95 Sigsbee Rd., Box 915. 6-9803

MIAMI
Gulfstream Astronomical Ass'n., Inc. *†
H. A. Thompson, 1118 Alberca, Coral Gables. HI 8-2873
Southern Cross Astronomical Society, Inc. *†
A. P. Smith, Jr., 1601 S.W. 10th St. FR 4-7145

ORLANDO
Amateur Astronomy Club of Orlando *
Mrs. R. Lee, 445 Rock Lake Dr. 5-9000

ST. PETERSBURG
St. Petersburg Amateur Astronomy Club *†
Mrs. J. D. Rains, 2830 10th Ave. N. 79-9854

TAMPA
Tampa Amateur Astronomical Society †
E. Z. Randall, 407 W. Chelsea St. 33-6391

WEST PALM BEACH
Astronomers Club of the Palm Beaches †
Mrs. D. D. Sinclair, Box 1108. JU 2-6830

GEORGIA

ATLANTA
Atlanta Astronomy Club *†°
W. H. Close, 225 Forkner Dr., Decatur. DR 3-3945

MACON
Macon Amateur Astronomers Club *†
P. E. Haines, 505 Eldorado Dr. 5-5084

HAWAII

HONOLULU
Hawaiian Astronomical Society *
E. G. Linsley, B. P. Bishop Museum (17).

IDAHO

BOISE
Boise Astronomical Ass'n.
Miss L. Moulton, 1712 N. 28th.

IDAHO FALLS
Idaho Falls Astronomical Society *
Mrs. O. D. Hendrickson, 475 J St. JA 2-3474

ILLINOIS

CHICAGO
Chicago Astronomical Society *†
A. A. Hay, 8024 W. Winnemac Ave. (31).
Chicago Junior Astronomical Society †‖
E. Zimmermann, 133 Franklin Ave., River Forest. FO 9-8186
Lincoln Park Astronomical Society ‖
D. Fretland, 509 W. Deming Pl. (14).

DANVILLE
Danville Astronomical Society †‖
D. D. Morrison, 5 E. Fairchild.

GALESBURG
Galesburg Amateur Astronomers *†
H. L. Horein, 1246 N. Morton Ave. 7337-2

GENEVA
Fox Valley Astronomical Society *
J. Zoda, 420 Fellows St., St. Charles. 5507

LEMONT
Argonne Astronomy Club *†
H. DaBoll, Box 299, Argonne Nat'l. Lab. 800, ext. 2711

LOMBARD
Tree Towns Astronomy Club †‖
L. Ewing, 26 S. Westmore Ave. 4153-J

MOLINE
Popular Astronomy Club *†
H. J. Schieck, 3303 Coaltown Rd.

OAK PARK
Sirius Astronomical Society †‖
Miss C. Resnick, 722 N. Lombard Ave. EU 6-4742

PEORIA
Astronomy Section, Academy of Science
R. P. Van Zandt, 1100 N. Parkside Dr. 4-5621

ROCKFORD
Rockford Astronomical Society ‖
W. Fonvielle, 528 Howard Ave. 8-5969

INDIANA

EVANSVILLE
Evansville Astronomical Society *†
Dr. R. T. Dufford, 512 S. Weinbach Ave. (14). GR 6-7856

INDIANAPOLIS
Indiana Astronomical Society *†°
W. E. Wilkins, 6124 Dewey Ave. FL 7-5946

KOKOMO
Kokomo Astronomical Society *
P. Miles, Box 645. GL 2-9378

MADISON
Madison Junior Astronomy Society *‖
T. A. Winkel, 607 N. East St.

SOUTH BEND
St. Joseph Valley Astronomical Society
Miss I. Debruycker, 1023 S. Union St., Mishawaka. BL 5-0560

IOWA

DES MOINES
Des Moines Div., Great Plains Astronomical Soc.
D. P. Cruikshank, 3655 67th St. (10). CR 7-5852

MARSHALLTOWN
Central Iowa Astronomers *
J. C. Steffa, 404 E. Church St. 2-1264

WATERLOO
Northeast Iowa Div., Great Plains Ast. Soc. *†
C. P. Martens, Rte. 4, Charles City. 2152-M

KANSAS

TOPEKA
Topeka Astronomical Society
D. Helm, 224 Buchanan St. 3-9307

WICHITA
Wichita Astronomical Society *†
S. S. Whitehead, 425 N. Lorraine (8). MU 2-6642

KENTUCKY

LOUISVILLE
Louisville Astronomical Society †
Mrs. V. C. Lipphard, 2421 Calvin (6). TW 6-9084
Louisville Junior Astronomical Society *†‖
D. Kleinman, 1414 Goddard (4). HI 1365-J

LOUISIANA

GRETNA
Gretna Astronomical Society
J. A. Gunther, 209 Newton St. FO 1-0034

LAKE CHARLES
Lake Charles Amateur Astronomers Club †
C. Fronczek, Rte. 1, Box 51, Westlake. HE 6-1797

METAIRIE
New Orleans Soc. for Advancement of Astronomy
J. Mickel, 1307 Ridgelake Dr. VE 5-0766

NEW ORLEANS
New Orleans Amateur Astronomers Ass'n.
W. E. Wulf, 2107 Annunciation St. (13). RA 0706

OPELOUSAS
Opelousas Amateur Astronomers Ass'n.
Dr. W. G. Owen, IV, 311 E. Tennis St. 3812

MARYLAND

BALTIMORE
Baltimore Astronomical Society *
Maryland Academy of Sciences, Pratt Libr. Bldg., 400 Cathedral St. (1). MU 5-2370

MASSACHUSETTS

CAMBRIDGE
Amateur Telescope Makers of Boston *†
R. E. Cox, 32 Shepard St. (38). EL 4-3536
Bond Astronomical Club *†
R. C. Smith, 519 Morrissey Blvd., N. Quincy (71). GR 2-1938

SPRINGFIELD
Springfield Stars Club *‡°
J. E. Welch, 107 Lower Beverly Hills, W. Springfield. RE 4-9179

WEST HARWICH
Cape Cod Astronomy Club *
C. Perisho.

WORCESTER
Aldrich Astronomical Society *†
T. L. Agos, 1 W. Boylston Terr.

MICHIGAN

BATTLE CREEK
Battle Creek Amateur Astronomy Club ‡
Mrs. W. V. Eichenlaub, 47 Everett Ave. 2-3059

DETROIT
Detroit Astronomical Society, Inc. *†
T. W. Sulisz, 3310 Dartmouth (17). WA 8-8949

FLINT
Flint Astronomy Club ‡
Mrs. I. Majeski, 610 Grace St.

GRAND RAPIDS
Grand Rapids Amateur Astronomical Ass'n. *†
J. C. Veen, Sr., 2100 Francis Ave. S.E. (7). CH 3-3098
Grand Rapids Junior Astronomical Society ‖
B. Hymes, 1500 Seminole Rd. S.E. CH 1-1460

JACKSON
Jackson Astronomical Society
W. H. Ketts, Jr., 2901 Robinson Rd. ST 2-9731

KALAMAZOO
Kalamazoo Amateur Astronomical Ass'n. ‡
Mrs. V. Shellman, 3809 Allendale. FI 4-8295

LANSING
Lansing Amateur Astronomers *†
R. C. Elliott, 434 Cowley Ave., E. Lansing. ED 2-5241

PONTIAC
Pontiac-Northwest Detroit Astronomers Ass'n. *†
G. Carhart, 40 Hadsell Dr. FE 2-9980

SAGINAW
Saginaw Valley Astronomical Ass'n. *
G. C. Farnum, 1224½ Lapeer St.

STURGIS
Sturgis Astronomy Group
Mrs. S. Butler, 805½ E. Main St. 464-J

MINNESOTA

EDINA
Edina Astronomy Club *†
D. Lane, 4006 W. 44th St.

MINNEAPOLIS
Minneapolis Astronomy Club ‡
Mrs. M. B. Haarstick, Science Mus., Pub. Libr. FE 8-0781
Minneapolis Junior Astronomy Club *‖
Mrs. M. B. Haarstick, Science Mus., Pub. Libr. FE 8-0781

ST. PAUL
St. Paul Telescope Club *†
F. F. Miller, 1212 7th Ave. S., S. St. Paul. GL 5-5934

MISSOURI

FAYETTE
Central Missouri Amateur Astronomers *†
R. C. Maag, 820 S. Osage, Sedalia.

KANSAS CITY
Astronomy Club of Kansas City *†
Mrs. L. Kinsey, 1522 Brush Creek. WA 3-3410

ST. LOUIS
St. Louis Astronomical Society *†
Mrs. N. Fallert, 9804 Honeycut Lane (19). WO 1-8427

MONTANA

HELENA
Amateur Astronomy Club of Helena ‖
Dr. T. J. Mentrum, 504 Power Bldg. HI 2-0293

NEBRASKA

OMAHA
Omaha Div., Great Plains Astronomical Soc.
R. Osborn, 2035 N. 53 St. GL 5431

NEVADA

RENO
Astronomical Society of Nevada ‡
A. A. Garroway, 2040 Meadow View Lane. FA 3-0696

NEW HAMPSHIRE

NEWMARKET
Great Bay Amateur Astronomers *
Miss A. Geoffrion, Packers Falls Rd.

NEW JERSEY

CALDWELL
West Essex Astronomical Society
R. M. Greenley, 412 Bloomfield Ave. CA 6-6751

EATONTOWN
Society of Telescopy, Astronomy and Radio *
Mrs. T. B. Richey, 2038 Magill Dr. EA 3-1000, ext. 23114

JERSEY CITY
Gregory Mem. Obs. of Paul Revere Boys Club †‖
P. J. Kocmalski, 339 Wayne St. (3).

PATERSON
North Jersey Astronomical Society
D. Trombino, 4-4D Alabama Ave. (3). MU 4-6867

ROSELLE PARK
Amateur Astronomers of Union County *†
Mrs. D. A. Carlisle, 97 West End Ave., N. Plainfield.

RUTHERFORD
Astronomical Society of Rutherford
Mrs. A. Cox, 478 Riverside Terr. WE 9-0453

TEANECK
Bergen County Astronomical Society †
P. A. Zipperle, 3 Golf Ave., Maywood.

NEW MEXICO

LAS CRUCES
Astronomical Society of Las Cruces *‡‡°
J. E. Durrenberger, Box 625. JA 6-2968

ROSWELL
Pecos Valley Sky and Telescope Club *
Dr. R. R. Boice, Rte. 2, Box 163-A. MA 2-7171

NEW YORK

ALBANY
Albany Astronomical Ass'n. *†
A. L. Swider, 42 Hanes St. (3). 8-3784

BABYLON
Long Island Observers' Ass'n. *
J. A. Tosto, 8 Bacon Lane. MO 9-9173

BINGHAMTON
Astronomical Society of Broome County
Dr. S. D. Molyneaux, Jr., 22 Murray St. 4-4620

BROOKLYN
Junior Astronomy Club †‖
S. E. Strom, 1950 Andrews Ave., Bronx (53).

BUFFALO
Buffalo Astronomical Ass'n. *†
G. N. Rote, 82 Floradale Ave., Tonawanda. AM 8150

CORNING
Corning Astronomy Club *
Mrs. E. Johnston, 106 Jennings St. 2-5142

JAMESTOWN
Astronomers Guild of Jamestown *
B. Hanson, 613 Stowe St. 92-811

NANUET
Rockland Astronomical Society
A. Goldsmith, 29 W. Allison Ave., Pearl River.

NEW YORK
Amateur Astronomers Ass'n., Inc. *
Mrs. A. Pridmore, 201 W. 79th St., Room 1010 (24). EN 2-7100

ROCHESTER
Astronomy Section, Academy of Science †
Miss J. M. Brown, 460 Campbell St. (11). GE 8-7284-M

SCHENECTADY
Schenectady Astronomy Club *†°
C. E. Johnson, 102 State St. DI 6-9522

SYRACUSE
Syracuse Astronomical Society *†
C. D. Fuller, 130 Falls Blvd., Chittenango. NE 7-3395

TROY
Rensselaer Astrophysical Society *†
Dr. R. Fleischer, Rensselaer Polytechnic Inst. AS 2-4678
Troy Astronomy Club †
J. T. Watkins, Valley Falls. PL 3-4195

UTICA
Utica Amateur Astronomers *†
W. Burak, Sr., 1663 Lincoln Ave.

WANTAGH
Long Island Astronomical Society
A. R. Luechinger, 2009 Seaford Ave. SU 5-1571

NORTH CAROLINA

CHAPEL HILL
Chapel Hill Astronomy Club *†
Miss M. I. Perry, 9 Maxwell Rd. 9-6334

CHARLOTTE
Charlotte Amateur Astronomers Club *‡
F. Selby, 200 S. Laurel Ave. (7). ED 3-3933

GREENSBORO
Greensboro Astronomy Club *†
Dr. A. D. Shaftesbury, 315 Tate St. 2-6528

WINSTON-SALEM
Forsyth Astronomical Society *†
K. A. Shepherd, 903 West End Blvd. 2-1631

NORTH DAKOTA

GRAND FORKS
Red River Astronomy Club *†
L. B. Speare, 1925 Viets Ave. 4-4705

OHIO

AKRON
Astronomy Club of Akron *
Mrs. R. J. Couts, 878 Kennebec Ave. (5). ST 4-8450

BAY VILLAGE
Lake Erie Jr. Museum Junior Astronomers †‖
Mrs. E. W. Fleming, 630 Canterbury Rd. TR 1-3742

CINCINNATI
Cincinnati Astronomical Ass'n. *
G. A. Lineback, 2933 Cortelyou Ave. JE 1-1442
Cincinnati Astronomical Society, Inc. *†
Mrs. D. H. Watson, 1832 Waltham Ave. (24). WE 1-5919

CLEVELAND
Cleveland Amateur Telescope Makers
Museum of Natural History, 2717 Euclid Ave. PR 1-0909
Cleveland Astronomical Society
Warner and Swasey Obs., Taylor Rd., E. Cleveland (12). GL 1-5625

COLUMBUS
Battelle Astronomy Club *
J. W. Kissel, Battelle Mem. Inst., 505 King Ave. AX 9-3191, ext. 363-2330
Columbus Astronomical Society *†
Mrs. J. Gann, 420 N. Cassady Rd. (9). CL 2-8421

DAYTON
Dayton Astronomy Club *
R. Walters, 5384 Cornwall Dr. (15).
Miami Valley Astronomical Society *†
F. E. Sutter, 5038 Far Hills Ave. (59). AX 3-1827

ELYRIA
Black River Astronomical Society *
G. Diedrich, 653 Weller Rd. 44-033

HILLSBORO
Hillsboro Astronomical Society *
Mrs. D. N. McBride, Box 85. 1169

LIMA
Lima Astronomy Club *
Mrs. R. E. Kampf, 478 N. West St. 4-8391

MARIETTA
Marietta Astronomical Society *
Miss L. E. Cisler, Cisler Terr. FR 3-0231

NEWARK
Newark Astronomical Society
G. Cooperrider, 326 N. 11th St. FA 3-0452

TOLEDO
Toledo Astronomical Society
E. D. Edenburn, 4124 Commonwealth Ave. (12). CH 3-3558

WARREN
Mahoning Valley Astronomical Society
Mrs. G. R. Prather, 1363 Drexel Ave. N. W. 4494-2

YOUNGSTOWN
Youngstown Astronomy Club *
A. Luszez, 141 E. Delason Ave. RI 4-3836

OKLAHOMA

TULSA
Astronomy Club of Tulsa *†
R. F. Reid, 1948 E. 14th St. WE 9-5286
Oklahoma Astronomical Society *‡‖
L. Dicken, 1332 S. Sandusky (12). MA 6-9644

OREGON

GRANTS PASS
Rogue Valley Astronomers and ATM's
H. R. Dickey, 1587 E. Fruitdale Rd.

PORTLAND
Amateur Telescope Makers and Observers ‡‡°
Miss V. Babin, 3038 N. E. 56th Ave. (13). AT 7-9405
Portland Astronomical Society *†
Mrs. M. Krutsinger, 6525 N. E. Davis (16). AL 4-1491

SALEM
Salem Astronomical Society *
Mrs. B. W. Christensen, 1425 Marshall Dr.

PENNSYLVANIA

BEAVER
Beaver County Amateur Astronomers Ass'n. *†
R. Weertman, 595 Dravo Ave. SP 5-0066

BUTZTOWN
Lehigh Valley Amateur Astronomical Soc.
E. A. Bodder, Box 133.

HARRISBURG
Astronomical Society of Harrisburg *†
E. L. Naylor, 320 Wilhelm Rd. CE 2-6479

MILLVALE
Shaler Township Junior Amateur Astronomers ‖
C. Raible, 200 Rebecca Sq. (9). TA 1-2171

PHILADELPHIA
Amateur Astronomers of Franklin Inst. †
E. F. Bailey, Franklin Inst. (34). LO 4-3600
Rittenhouse Astronomical Society *†
J. W. Streeter, Franklin Inst. (34). LO 4-3600

PITTSBURGH
Amateur Astronomers Ass'n. of Pittsburgh *†°
F. M. Garland, 127 Park Pl., McKnight Village (9).

SPRINGDALE
Allegheny Valley Amateur Astronomers *°
W. E. Stocks, 215 Carson St. SP 1980-W

WASHINGTON
Washington County Astronomy Club *
Mrs. L. Withrow, R.D. 1, Eightyfour. WI 1-7191

WAYNESBORO
Astronomical Society of Waynesboro *
R. H. Helfrick, R.F.D. 3. 1908-R1-4

YORK
York Astronomical Society *
J. N. Lewis, 157 Scarboro Dr. 8-1080

RHODE ISLAND

NORTH SCITUATE
Skyscrapers, Inc.
H. W. Preston, Bishop Heights. SC 1-3256

SOUTH CAROLINA

HARTSVILLE
Hartsville Astronomical Society ‖
B. Hopkins, Box 423. 1540

SOUTH DAKOTA

RAPID CITY
Rapid City Astronomical Society *
Dr. R. F. Heckman, S. D. State School of Mines and Technology.

TENNESSEE

BRISTOL
Bristol Junior Astronomical Society *‖
H. Snow, 618 Center Dr.

CHATTANOOGA
Barnard Astronomical Society *†
A. H. Jones, 411 W. 21st St. VE 1-2244

KINGSPORT
Kingsport Astronomical Society *
J. Brown, 1329 Belmeade Dr. CI 5-7513

MEMPHIS
Memphis Astronomical Society *†
S. P. Franklin, 5030 Lynbar. MU 3-9737

NASHVILLE
Barnard Astronomical Society *
Dr. C. K. Seyfert, Vanderbilt Univ. AL 4-5611

PORTLAND
Portland Astronomical Society †
R. O. Riggs, Box 42. 3781

TEXAS

ABILENE
Abilene Astronomical Society *
R. B. Edmundson, 1849 N. 8th St. OR 4-5932

BROWNFIELD
Brownfield Astronomy Club *
C. Isbell, Rte. 1. 2074

DALLAS
Texas Astronomical Society †°
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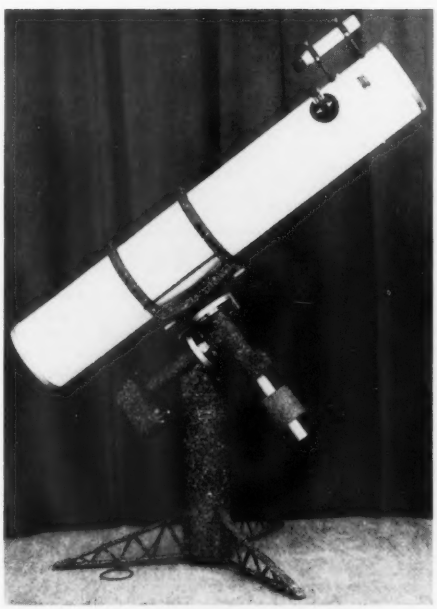

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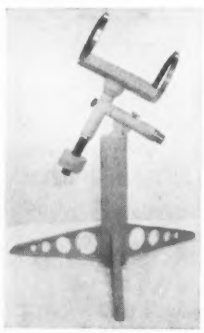

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OBSERVER'S PAGE

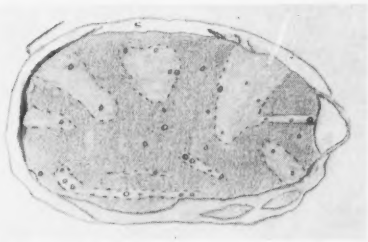
Universal time is used unless otherwise noted.

MAPPING THE FLOOR OF PLATO

LAST August I started systematic observations of features on the floor of the lunar crater Plato, using the 8-inch reflector belonging to my high school science club. The drawing on page 22 of the November, 1957, *Sky and Telescope* shows many of the tiny craterlets and bright spots visible in this telescope under favorable conditions. Because these markings have long been suspected of year-to-year changes in visibility, I decided to make a careful chart of them as they appeared in 1957.

The accompanying map is based upon 15 sketches made between August and December last year. Next to each feature on the map is its "visibility index number," which is the percentage of observing nights on which it was recorded. These numbers provide a rough scale of the relative conspicuousness of the different features, and hence should be useful in any comparison with the work of other observers to detect changes. Italic numbers on the chart indicate doubtful objects, glimpsed faintly only once or twice; some of these could have been confused with neighboring markings.

The total number of spots charted was 64, five of which could be recognized as small craterlets by their interior shadows. The most seen on a single night was 39 on October 11th, but over 30 were counted on five nights, and in all but four of my sketches there were 18 or more. After the map had been completed, on one night of exceptionally steady seeing, January 2, 1958, I saw 38 interior spots, and made the pencil sketch reproduced above.

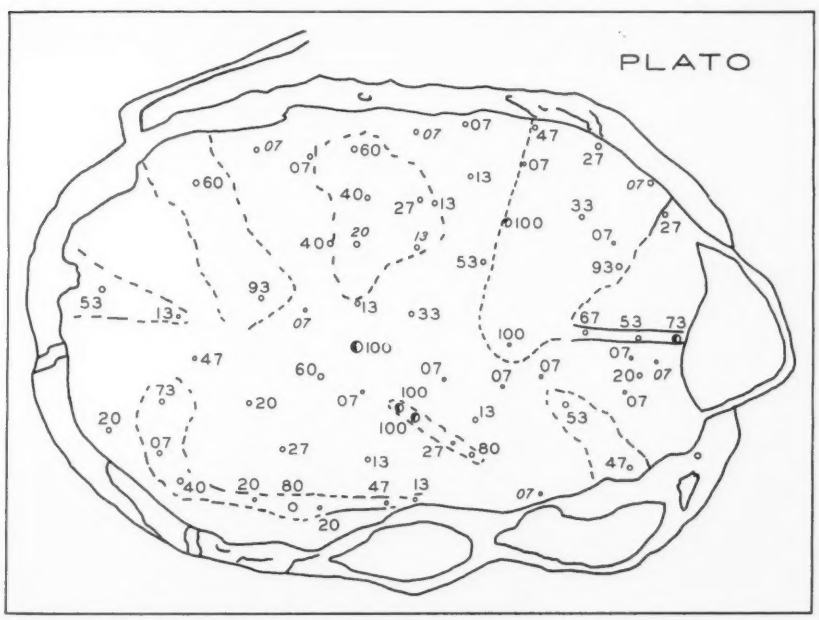


A sketch of Plato at 200x, made January 2, 1958, 0:40 to 2:15 Universal time, with an 8-inch telescope.

All but a few of the spots are invisible at sunrise on this portion of the moon, when the moon's age is between eight and nine days. At no time did any part of the floor appear to be obscured, as some observers have reported.

One problem of Plato is whether its floor follows the curve of the moon's surface, or has some low relief. Sketches made on two nights when it was near sunrise on Plato seem to me to indicate that the floor is rolling. On September 3rd there was a low place just east of the prominent central craterlet; west of this same crater there was an area slightly brighter than the rest of the floor, apparently the eastern slope of another depression. On October 3rd, both these areas appeared dark.

PATRICK McINTOSH
R. R. 2, Box 231
Robinson, Ill.



In this Patrick McIntosh chart, compiled from observations at 200x to 400x, dashed lines depict lighter patches on the dark floor of Plato.

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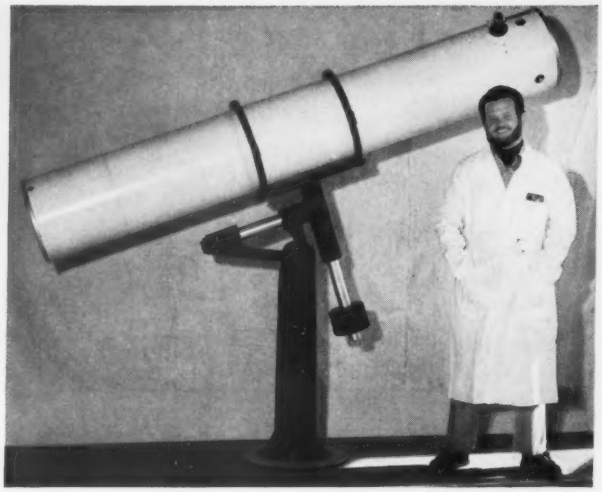

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6-inch

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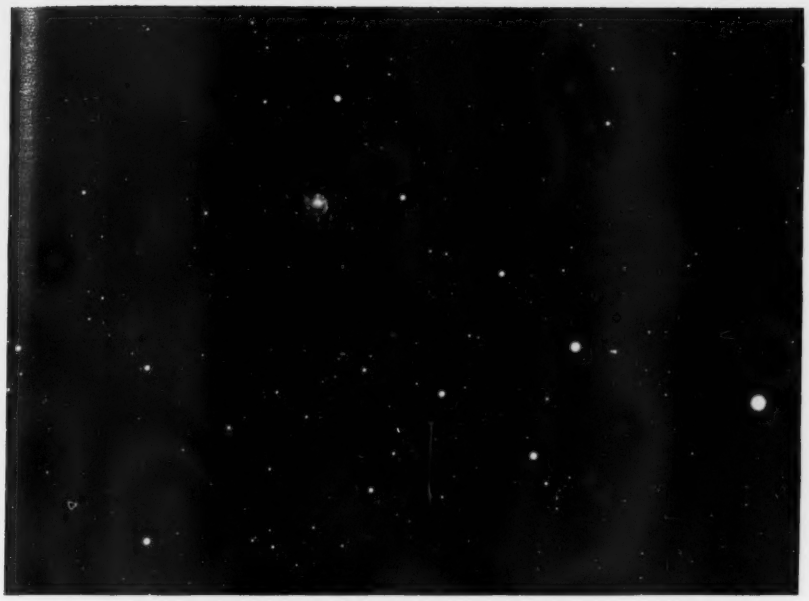

The region of the spiral galaxy M101, from a Harvard Observatory photograph with the 16-inch Metcalf refractor on February 28, 1935, exposure three hours. North is at the top, west toward the right. The spiral structure of M101 is well recorded, while NGC 5474 is visible in the lower left. The star 86 Ursae Majoris is the brightest one in the field, at the right edge.

DEEP-SKY WONDERS

WE have noted before that Ursa Major and its surroundings are surprisingly rich in spiral nebulae, including such conspicuous objects as M51, M94, and M101. The last of these is a bright pinwheel, spinning in aeon-long rotation, and almost perfectly broadside.

M101, also called NGC 5457, lies just off the handle of the Big Dipper, at right ascension $14^h\ 01^m.4$, declination $+54°\ 35'$ (1950 co-ordinates). Its visual magnitude is listed as 9.2 by Holetschek and as 8 in Gingerich's edition of Messier's catalogue. Thus, M101 is an easy object in practically any telescope, although larger apertures give a distinct advantage, as always. In my 10-inch telescope it shines fairly bright, with just a hint of major arms — not enough to demonstrate its spiral nature without preknowledge. It is easy to find and simple to recognize, high in the sky on April evenings.

On long-exposure photographs M101 looms large, its 22′ diameter being two-thirds that of the full moon; intricate and delicate detail is recorded in the trailing spiral arms.

Admiral Smyth, in his *Cycle of Celestial Objects* of 1844, lists this object under Bootes and comments: "It is one of those globular nebulae that seem to be caused by a vast agglomeration of stars, rather than by a mass of diffused luminous matter . . . the paleness tells of its inconceivable distance." Thus, he anticipated the system's true nature nearly 80 years before Hubble's final proof that the spiral nebulae are distant milky ways. Curiously, Reverend T. W. Webb omits M101 in his great *Celestial Objects for Common Telescopes* (last edition, 1917).

Nearby are three fainter objects, which the amateur without setting circles may find by using M101 as a guide. These objects, each of approximately visual magnitude 11.5, are: NGC 5473, a barred spiral 1′.2 long, at $14^h\ 03^m.0$, $+55°\ 08'$; NGC 5474, a spiral 4′ in diameter, at $14^h\ 03^m.2$, $+53°\ 54'$ (seen below and slightly to the left of M101 in the accompanying field picture); and NGC 5485, an elliptical galaxy 0′.9 across, at $14^h\ 05^m.5$, $+55°\ 14'$.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

SUNSPOT NUMBERS

The following American sunspot numbers for January were derived by Dr. Sarah J. Hill, of Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

January 1, 213; **2,** 222; **3,** 195; **4,** 218; **5,** 185; **6,** 120; **7,** 225; **8,** 212; **9,** 187; **10,** 249; **11,** 243; **12,** 269; **13,** 235; **14,** 279; **15,** 223; **16,** 300; **17,** 240; **18,** 215; **19,** 198; **20,** 178; **21,** 203; **22,** 229; **23,** 143; **24,** 123; **25,** 184; **26,** 198; **27,** 142; **28,** 129; **29,** 118; **30,** 155; **31,** 144. Mean for January, 199.2.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

February 1, 138; **2,** 148; **3,** 146; **4,** 144; **5,** 148; **6,** 156; **7,** 156; **8,** 157; **9,** 164; **10,** 157; **11,** 165; **12,** 177; **13,** 163; **14,** 174; **15,** 154; **16,** 129; **17,** 135; **18,** 137; **19,** 139; **20,** 145; **21,** 152; **22,** 150; **23,** 160; **24,** 145; **25,** 187; **26,** 160; **27,** 141; **28,** 118. Mean for February, 151.6.

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Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.3-mm. (⅔″ focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

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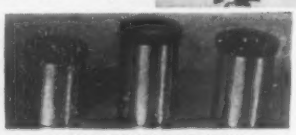

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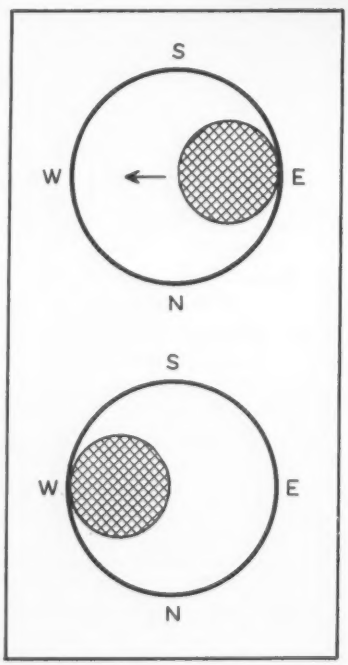
With a camera of short focus fastened along the tube of a telescope of long focus, it is possible for an amateur to obtain photographs of fair quality, even if slow-motion controls or a clock drive are not available. I took the accompanying picture of Orion with an f/4.5 camera of 6-inch focus, mounted on a 4-inch refractor that was used for "guiding," although it had no mechanical drive of any kind.

With the telescope stationary, a bright star in the region to be photographed required about 25 seconds to drift across the field of a ¼-inch eyepiece. The star image was then put out of focus until it covered half the diameter of the field. The telescope was set so the edge of the expanded star disk just touched the eastern edge of the field. The disk took just about 12 seconds to drift across the field until it touched the western side. Then I carefully moved the telescope westward in hour angle until the star image once more touched the eastern edge and another 12-second trip began.

Thus, five times in one minute, or 50 times in 10, I reset the telescope. When an actual 10-minute exposure was made, the developed 4 x 5 negative contained acceptable star images. Therefore, I tried my hand at 60-minute exposures. After 15 minutes I tired, so I closed the camera shutter and "took five" to have a smoke and stretch. The guide star was easily picked up again, and the exposure continued.

This photograph of the central region of Orion was made by H. W. Seekins without benefit of clock drive or slow-motion controls. "Guiding" was intermittent, with the telescope actually stationary for 55 minutes during the hour-long exposure. The Belt of Orion is in the middle, with the Sword and the Great Nebula below it. Rigel is in the lower-right part of the field.



In the upper diagram, the out-of-focus star image is at the start of its 12-second drift westward, to the position shown in the lower diagram. After this the telescope is gently moved to return the star to the eastern edge of the field of view.

Two precautions are very necessary with this method. A cable release should be used with the camera to avoid jarring it or moving it. The telescope must be equipped with a good equatorial mounting that is accurately aligned with the celestial pole; otherwise, the stars will trail slightly in declination and the images will be elongated from north to south.

The permissible duration of the guide star's trip across the field of view varies with the focal lengths of the camera and the telescope. The shorter the camera focal length, the longer the safe trailing time is. However, for 35-mm. or No. 120 cameras, where enlargements to 5 x 7 or 8 x 10 are desired, it is best to test by a series of trial exposures, each with a different trailing time. In my one-hour picture, nearly 300 12-second exposures are piled on one another!

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PREVIEW

The apparatus on the table is a high-precision laboratory test frame holding the optics of a new 7-inch Questar. Beside it at the left is a caliper with its jaws set one foot apart, to illustrate that only 12 inches separate the 7.6-inch mirror from its front correcting lens. These elements will finally go into an 8-inch tube just 16 inches long. Think of it—a superfine 7-inch Questar only a foot and a third in length!

Short telescopes are our business. We have now made more compound telescopes than all other present-day manufacturers combined. Four years ago we introduced the new catadioptric lens-and-mirror optics to the world in the famous 3½-inch Questars which have so ably demonstrated what the superfine small telescope can do.

So far as we know, these were the first Cassegrain telescopes with f/2 primary mirrors ever put into commercial production. If you look about, you will find no other instruments so drastically reduced in length.

Why do we stress this vital shortness? The reason is really very simple, and important, too. For if you are willing to go to the very considerable trouble and expense of figuring steep curvatures like these to a whole new order of ultra-precision, something wonderful takes place. You no longer need the long tube and great weight of clumsy instruments designed two centuries ago. Gone, too, is the necessity for dome or shed, or massive mounting of fixed one-purpose installations. Gone is the huge tripod, the trembling tube, the faltering drive, and the coffinlike set of boxes of so-called "portable" small telescopes. Good riddance, too. In its place you now may have a featherlight, rock-steady compact instrument of graceful and felicitous performance.

There are other special virtues, too, that flow from this design of ours. For example, these aspheric optics are not a matter of mass manufacture, but the result of the careful nurture of each surface in its marriage with a complementary curvature. Hand retouching further reduces the already low residual errors of more simple, spherical catadioptric systems. It is good to see the quickening of interest in these most rewarding systems, and pleasant to recall that Questar Corporation was the first to put them on the market.

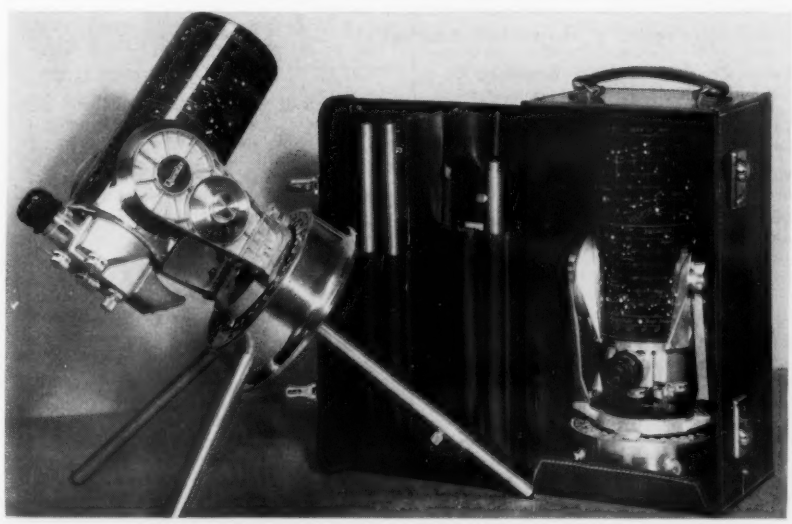
Many of the exclusive Questar features will be used in the new 7-inch. It will have the centrally supported major mirror, and internal focusing which permits the freedom of a movable focal plane for the best employment of accessories. Just as the little Questars have useful focal lengths of from 3½ to 30 feet, so their big brother, with twice the resolution and four times the light grasp, will deliver focal lengths of from 7 to 60 feet and more.

Production Manager John Schneck (standing) and President Lawrence Braymer inspect the test rig for the 7-inch Questar just completed by Master Mechanic Ernest Arndt (at left).

This 7-inch will hold its own with many larger instruments. Despite its 16-inch length and total weight of only 40 pounds, we expect it to give fine 8-inch refractors and all 12-inch reflectors a very hard time in any climate, any air. Consider the advantage it will have in the important matter of internal tube currents. This is our thinking: that no 7-foot open tube or 12-foot closed and baffled tube can be so free of drafts and thermal eddies as our little 16-inch barrel. It will suffer less from inside turbulence, while its smaller aperture will be less affected by external causes of poor seeing.

The weight and cost of telescopes usually increase as the cube of a dimension. In going to 7 inches from 3½, the weight of the front lens becomes exactly 8 times greater than the smaller one, so the factor of increased weight is 8. But by careful design and by making the instruments in groups, we think the price can be held below $5,000. Our guess would be that this represents a saving of some $20,000 in comparison with the cost of building and housing an 8-inch refractor.

Deliveries are scheduled for this autumn. At present the details of mounting are flexible. If this larger Questar interests you, please write and tell us of your requirements and give us the benefit of your thinking. Instruments may now be reserved for late '59 delivery.



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BOOKS AND THE SKY

THE INNER METAGALAXY

Harlow Shapley. Yale University Press, New Haven, Conn., 1957. 204 pages. $6.75.

A GALAXY is "a *large* gravitational system of stars." The metagalaxy is "the total recognized assemblage of galaxies" and "includes also whatever there may be in the way of gas, particles, planets, stars, and star clusters in the spaces between the galaxies."

The space encompassed by Harlow Shapley's book, *The Inner Metagalaxy*, is a sphere around us that is far more voluminous than any single stellar system, yet much smaller than the total region that can be surveyed with the largest telescopes. In essence, it is the realm occupied by the half-million galaxies photographed during Harvard's monumental 18th-magnitude survey, reaching out, for galaxies of average luminosity, to 150 million light-years (or more, as Hubble's parameter continues to dwindle).

The major emphasis in this book is on the results of the Harvard all-sky survey with the 24-inch Bruce camera in South Africa and the 16-inch Metcalf camera in Massachusetts. Here in one volume, replete with diagrams and references, are usefully summarized the findings of more than a hundred separate publications that have been issued over the last three decades. To paraphrase the author's words, the book's justification is that it memorializes the end of an era and celebrates the birth of a new one. The old era saw the first large-scale canvass of faint galaxies — the stuff of the inner metagalaxy. The new era witnesses the Lick galaxy-count program, the deeper survey by the Palomar Schmidt, and the census taking of extragalactic discrete sources with high-resolution radio telescopes.

Dr. Shapley stresses that the data out of which the book is woven are often of rather rough texture. The stellar magnitude standards of the southern celestial hemisphere were fairly crude; accurate estimates of interstellar extinction were hard to come by; and derivation of the limiting magnitude of each photograph had to depend on star-count statistics. Because of such difficulties, the reader who has a well-developed hindsight will find it easy to criticize some of the results of the Harvard survey. But one who is noisy in his criticism fails to recognize pioneering work; he might still be censuring Herschel for having run the risk of deducing the solar motion from the proper motions of only 13 stars (if Herschel hadn't been right).

Among the many special surveys the author describes are those covering the two galactic polar caps, the two celestial polar caps, the rich canopy region between the north galactic and north celestial poles, and the five-degree circuit of sky that transits close to the Massachusetts zenith. Galaxies were tallied by the tens of thousands in each of these six areas, and individual magnitudes estimated in some of the regions. Among the findings were the patchy obscuration at the north celestial pole, very large-scale changes in galaxy density over the south galactic cap, and an excess richness of the northern galactic hemisphere over the southern that extends as faint as 18th magnitude.

Also documented are the patient probings along the dusty southern Milky Way borders and through the galactic windows in the Milky Way. Here and there an external system shines through, bearing witness that our own galaxy's dust is not very dense along that direction. "Zone of avoidance" is the time-tested phrase that describes that part of the galactic belt where no galaxies are seen at all. But time-tested or not, it ought to be renamed the "region of obscuration." Dr. Shapley points out, "Behind the dust clouds of the Milky Way there is undoubtedly a more or less uniform population of external galaxies."

This comment is well borne out in the discussion of the Shapley-Ames 1932 survey of the 1,200 brightest galaxies. A new and welcome diagram in the book shows in galactic co-ordinates the locations of these bright systems, and its most obvious feature is that not a single one of the 1,200 lies within 10 degrees of the galactic circle. If galaxies "avoided" these directions at random, I calculate that there is less than one chance in 10^{100} of finding such a vacant belt in the sky! The Shapley-Ames survey, it should be added, stands unrivaled today as a complete source of information on the brightest exterior systems, and it is welcome news that G. de Vaucouleurs is revising and extending it.

The Magellanic Clouds are described as gateways to the metagalaxy. Their utility is twofold, for they are the nearest of galaxies and they contain mixed populations. The Magellanic chapter, reprinted from an earlier article, seems here and there to depart from the tone and coverage of the balance of the book. But, taken on its own, it makes good reading; and of particular interest is the review of the Cepheid period-luminosity correlation, a topic that bears constant restudy. To the reasons listed for the scatter in the period-luminosity diagram should be added a new and important one discussed by Sandage too recently for inclusion. The Cepheids of a given luminosity on the H-R diagram show a spread in color index and thus in surface temperature. Since, from physical considerations, temperature correlates negatively with pulsation period, Cepheids of assigned luminosity will show a spread in period.

Analysis of the local group of galaxies

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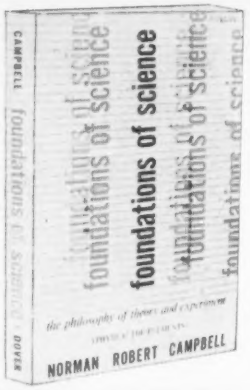

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(two of which have misnumbered NGC numbers on page 130) shows that the majority of the nearest score are dwarf spheroids and dwarf irregulars, whereas censuses of galaxies to a particular limiting magnitude reveal that giant spirals are in the majority. The reason for this paradox is not far to seek. When we count all objects down to a given brightness, only the extremely close subluminous ones are included, while the superluminous objects from very far away also make the list. Dr. Shapley makes the novel suggestion that our local group may not be the isolated colony of some 20 galaxies of all types that everybody thinks of today, but rather a group of six or eight big galaxies embedded in a continuous field of dwarfs. Stephan's Quintet in Pegasus and Seyfert's Sextet in Serpens exemplify such tight-knit groups.

Part of the text deals with our own galaxy, reviewing the many efforts to find out its size, its shape, the nature of its corona, and the location of its nucleus. Here one finds a brief and, I think, too-modest summary of Dr. Shapley's own 1917 work on the distribution of globular clusters, one of the major steps in the rollback of our physical horizons. Copernicus (foreshadowed by Aristarchus) removed our geocentric picture of the solar system; Bessel measured the distance to a star. Shapley (dimly anticipated by the Herschels) removed our heliocentric picture of the Milky Way; Hubble first measured the distance to a galaxy.

Although not dedicated to an over-all examination of the physical universe, as was the earlier *Galaxies*, the present book tells thoroughly the story of the great Harvard survey. One may count a few minor errors and note some repetitions. Altogether, though, any astronomer, professional or amateur, will find *The Inner Metagalaxy* a valuable addition to his bookshelf.

STANLEY P. WYATT, JR.
University of Illinois Observatory

THE PLANET VENUS

Patrick Moore. The Macmillan Company, New York, 1957. 132 pages. $3.00.

VENUS is rightly called the planet of mystery. Even the rotation period of this cloud-veiled neighbor is in doubt. The mystery is due to both the shortage of information and the scattering of this information among hundreds of magazine articles and reports. Patrick Moore collects many of the facts about Venus in this first book in English devoted to the planet.

Equally known as an astronomical author and amateur observer, Mr. Moore is director of the Mercury and Venus section of the British Astronomical Association. He has been observing Venus since 1934, when he was 11 years old, and few living astronomers have his familiarity with the visual appearance of our sister planet or his wide acquaintance with its literature. His easy style is very readable.

The Planet Venus deals mainly with direct visual examination of the planet. There are chapters on the dusky markings, the bright areas, and the cusp caps, as well as an appendix devoted to practical advice to the amateur observer. So heavy is the emphasis on direct telescopic inspection that the author seems to underestimate the value of the photographic studies by F. E. Ross, G. P. Kuiper, and A. Dollfus.

Their work shows that the dusky markings, usually so indefinite to the eye, are much more conspicuous on ultraviolet-light photographs. The reviewers feel that the observer who is dissatisfied with inconclusive, traditional working methods should consider systematic work by photography or image-converter tubes, if his instrumental equipment permits.

The rotation period of Venus, suggests Mr. Moore, may perhaps be three or four weeks, but he admits that the problem is still unsolved. The day of Venus cannot be equal to its year, he feels, since the measured temperatures of the planet's day and night sides are nearly equal; the rotation must be fast enough so the unilluminated half does not have time to cool appreciably.

One of the most intriguing phenomena of Venus is the occasional visibility of the nonsunlit portion, and Mr. Moore devotes a long section to this ashen light, summarizing many visual reports. However, the suggestion that the ashen light of Venus is analogous to the aurora did not originate with J. Lamp in 1887, but was discussed by P. de Heen in 1872. This is an example of the minor inaccuracies occasionally found in this book. Mr. Moore fails to mention that N. A. Kozyrev observed the spectrum of the night side of Venus with the 50-inch reflector of the Crimean Astrophysical Observatory, finding many molecular emission bands, as reported on page 159 of the February, 1956, issue of this magazine.

Another recent result, perhaps too late to have been included in the book, is the detection early in 1956 of radio emission from Venus at Ohio State University and the Naval Research Laboratory.

The Planet Venus is an excellent descriptive work, written primarily for amateurs. It is not a detailed account of current research by professional astronomers, which would require a quite different kind of book. In addition, the author often states only his own interpretation of controversial issues. But he does provide an extensive bibliography, and the reader who has access to an astronomical library can examine such questions for himself.

Amateur astronomers will welcome this introduction to a fascinating but comparatively neglected part of solar system studies.

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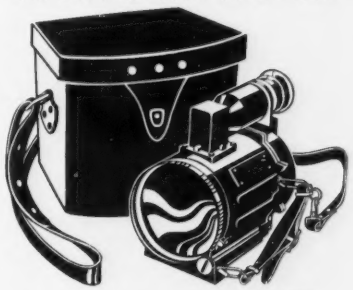

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NEW BOOKS RECEIVED

THE STARS, *W. Kruse* and *W. Dieckvoss*, 1957, *University of Michigan Press*. 202 pages. $5.00.

Two well-known astronomers of Hamburg Observatory have collaborated in a popular account of the stars, how they are observed, their properties, and the Milky Way system they form. The translation by Ralph Manheim is from the German edition of 1954.

WHITE DWARFS, *E. Schatzman*, 1958, *Interscience*. 180 pages. $5.50.

The author is a professor of astrophysics at the University of Paris who has long specialized in the study of white dwarf stars. This is the first book in English devoted exclusively to these objects.

Dr. Schatzman's technical account briefly outlines the observational data on white dwarfs, and deals in detail with the theoretical properties of dense matter, the internal structure of such stars, their energy generation, and their stability. The concluding chapter discusses the origin and evolution of these stars. An extensive bibliography follows each chapter.

DIE SONNE, *Karl Otto Kiepenheuer*, 1957, *Springer-Verlag*, Reichpietschufer 20, West Berlin W35, Germany. 150 pages. DM 7.80.

A leading German authority on solar astronomy gives an up-to-date account of what is known about the sun, with numerous illustrations. This work, in the German language, is the 68th volume in the Springer "Popular Science" series.

THE THRESHOLD OF SPACE, *M. Zelikoff*, editor, 1957, *Pergamon*. 342 pages. $15.00.

This book contains 45 papers given at the conference on chemical aeronomy held in Cambridge, Massachusetts, June 25-28, 1956, under the sponsorship of the Geophysics Research Directorate of the Air Force Cambridge Research Center. The papers cover such topics as the origin of the airglow, photochemical reactions in the upper atmosphere, and artificial meteors ejected from rockets. G. P. Kuiper has contributed a nine-page section on Venus' atmosphere.

GALILEO AND THE MAGIC NUMBERS, *Sidney Rosen*, 1958, *Little, Brown*. 212 pages. $3.50.

As a biography of the 16th-century scientist for readers 12 years of age and older, this book portrays the young Galileo, his education and early influences on his life, and his later triumphs and trials.

KLEINE METEORITENKUNDE, *Fritz Heide*, 1957, *Springer-Verlag*, Reichpietschufer 20, West Berlin W35, Germany. 142 pages. DM 7.80.

Meteorites are described in this revised edition of a popular work in German which first appeared in 1934. The topics include meteorite craters, the chemical and microscopical properties of fallen stones and irons, the origin of the small bodies of the solar system, and the nature of tektites. This volume is the second edition of No. 23 of the Springer "Popular Science" books.

THE SPACE ENCYCLOPAEDIA, 1957, *Dutton*. 287 pages. $6.95.

Introductory information about astronomy, rockets, and space travel is presented in brief, alphabetically arranged articles. For example, the four pages devoted to the letters J and K have sections on Jodrell Bank, Julian Calendar, Julian Date, June Draconids, Juno, Jupiter (two photographs and a diagram), K Corona, Kepler's Laws, Kinetic Energy, and Kirkwood Gaps. The eight-page illustrated article on the moon has an excellent lunar map. A five-page supplement, dated November, 1957, describes the first Russian artificial satellite, the Farside rocket, and the two recent bright comets, Arend-Roland and Mrkos.

Contributors to *The Space Encyclopaedia* include Sir Harold Spencer Jones, Homer E. Newell, Jr., and Patrick Moore. The editor is M. T. Bizony.

LOOKING AT THE STARS, *Michael Ovenden*, 1957, *Phoenix House, Ltd.*, 38 William IV St., Charing Cross, London W. C. 2, England. 192 pages. 10s 6d.

One of a series of books on leisure-time activities, this is an informal, chatty introduction to astronomy for beginners, by a leading British amateur astronomer. It is illustrated with diagrams and photographs.

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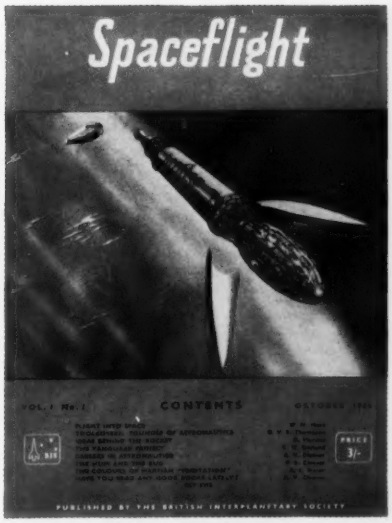

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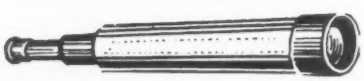

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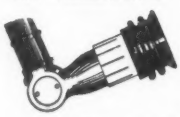
81 mm "	3¼" "	6.50
83 mm "	3¼" "	6.50
110 mm "	4⅜" "	10.50

3X TELESCOPE



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8" x 10"	4.25	4" x 4"	1.50

All mirrors are ¼" thick.

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More Maksutov Notes — Radius Testing

Tolerances. In many amateur-built telescopes, the radius of curvature of the primary mirror turns out quite different from the value the maker intended. He may accept a finished radius differing by as much as 12″ from the starting design, lengthening or shortening the tube to accommodate the final focal length.

Even in Cassegrainian telescopes, where tolerances are generally stricter, differences of 1″ or more in the radius of the primary mirror and 0.1″ in the secondary mirror radius are common. They can be compensated by changing the separation of the mirrors and the distance of secondary focus behind the main mirror.

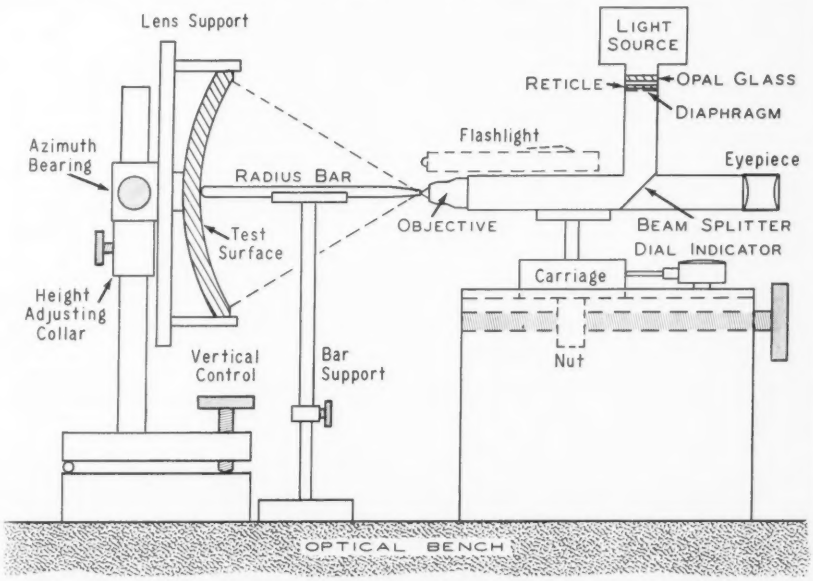
The curvatures of the surfaces of Maksutov optics must be held to quite strict tolerances (also true for a good objective lens). The steeper the curve, the closer it must follow the design figure. Take the case of John Gregory's f/15 Cassegrainian-Maksutov instrument, described in the March, 1957, *Sky and Telescope*, page 236. Its primary mirror has a radius tolerance of ±0.50″, but for the strongly curved correcting lens the radius tolerance is very small, ±0.070″ for both the concave front surface and the convex back surface. To make matters more difficult, the difference between these radii, 0.305″, cannot vary by more than ±0.004″. This provides a real challenge to the amateur telescope maker.

D. D. Maksutov (*Journal* of the Optical Society of America, *34*, 270, 1944) pointed out that amateur telescopes built to his empirical formulae will have aberrations well inside the Rayleigh limit. If during construction the specifications are met, an excellent instrument will result. He further showed how the remaining aberrations could be completely eliminated by making one of the optical surfaces aspherical. Such aspherizing would also compensate for differences between the construction and the design figures; and Mr. Gregory pointed out in his article that the radius-of-curvature tolerances could be increased 10 times.

Rather than alter any of the spherical surfaces, however, most amateurs will probably try to produce curves within the original design limits. This means strict radius control of all surfaces.

A simple radius tester. Few amateurs have the equipment to construct a precision spherometer that can accurately determine the radii of optical surfaces. Others would like to have some instrument to check the accuracy of a spherometer measurement. The low-cost tester described here will perform with an accuracy of 0.001″ or better, and, with a more expensive indicator, to within 0.0001″. The surface under examination must be concave, and polished or semi-polished; convex surfaces have to be tested against masters by interference, but these masters can be prepared using this instrument.

The tester is an optical device for comparing the radius of curvature of the surface with a radius bar, a steel rod whose length is exactly equal to the radius



The radius tester as used for checking the concave surface of a Maksutov corrector to an accuracy of 1/1,000 inch or better. The cone of light from the objective is focused on the end of the radius bar, broken lines indicating the path of the rays if the bar were removed.

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desired. The other components of the device are a microscope objective, beam splitter, light source, and measuring indicator.

The general layout of these parts is shown in the diagram. The image-forming unit can be made from a microscope tube, or the parts can be obtained separately and mounted in a tube. While a low-cost Japanese microscope could provide both objective and tube, a high-power microscope objective covering 55 to 60 degrees will be needed to illuminate the entire concave surface of the Maksutov lens. This requirement is not too serious, however, but at least two-thirds of the area under test should be covered.

The beam splitter can be a thin, flat piece of glass, partially coated to increase efficiency, or a prism-type beam splitter may be used. Either is obtainable from war-surplus optical dealers. The light source should be bright; an auto lamp with a step-down transformer is excellent. In front of the light are a piece of opal glass for diffusion and a diaphragm opening of about 3/32″ diameter. A war-surplus reticle cemented to the back of this hole will provide an etched line helpful in focusing. If a complete microscope is purchased, an eyepiece is already at hand; otherwise, an adapter may be made for a low-power astronomical ocular.

The simplest kind of measuring device suitable for the tester is a scale about 4″ or 6″ long, graduated in 0.010″ or 0.025″ divisions, and with a vernier scale reading to the nearest thousandth. Such scales may be secured from scientific supply houses and manufacturers of precision tools.

A very convenient alternative is a dial indicator, showing the movement of a piston in increments of 0.001″. More expensive, but particularly worthwhile, is a Brown and Sharpe dial indicator with 1″ plunger travel, reading to 0.0005″. The dial is 2¼″ in diameter, with a case of stainless steel, and costs about $22.

The most important piece of equipment is the radius bar against which the accuracy of the surface is checked. This should be a piece of steel drill rod, about ¼″ in diameter, and shaped as in the diagram. Few ATM's have access to micrometers with a span of over 6″, but a local machine shop can probably produce the rods at reasonable cost. For short rods, about 6″ long, specify the length to be equal to the radius desired with a tolerance of −0.0000″, +0.0005″. For the longer-radius mirror, a bar made to a tolerance of ±0.010″ is perfectly satisfactory.

Ask the machine shop to finish off the rounded end with fine emery paper. The tapered end should have its flat surface finished on fine crocus paper, the bar being held vertical and spun between the worker's palms. This will cause any scratches to form a circular pattern, an aid when centering the rod in the tester. Upon receiving the radius bars, the amateur should polish the ends slightly by spinning them as just described, but using a piece of felt and polishing compound. This will not remove any appreciable amount of stock.

Instead of such a radius bar, a rod-type adjustable inside micrometer can be used. For about $16.50 such an instrument can be secured from Sears, Roebuck and Co., adjustable from 2″ to 12½″, with an accuracy within 0.001″. Manufacturers of precision tools make such inside micrometers in a variety of sizes.

The diagram shows that the parts of the tester are mounted on what is practically a small optical bench, with several adjusting movements provided. The mount for the lens under test should be adjustable in azimuth and in a vertical plane, so that the optical axis of the lens can be aligned with that of the microscope objective.

When making measurements, however, the microscope should be the moving part, its travel indicating any difference between the test object's radius and the length of the radius bar. It is convenient to mount the unit on smooth parallel tracks, with a fine-thread screw to move it toward or away from the test surface. For rough settings, the holder for the latter can be arranged to slide on tracks toward or away from the microscope lens.

Using the radius tester. As the surface to be measured must have at least a semipolish, the tester is not employed during roughing out and preliminary smoothing with carborundum. During these stages an accurate template should be used for radius control. In the first stage of emery (say American Optical M302), about 10 minutes of the next finer grade (M303) will give the surface a rapid semipolish adequate for optical testing. Once beyond the M302 grit, the polish will suffice without further treatment.

Let us go through the steps in testing the radius of a steep concave lens, for example the front surface of the correcting lens of the Gregory f/15 Maksutov. The desired radius is 6.583″, and we have procured a radius bar of this length. The lens is fixed securely in its holder in front of the microscope assembly, and then adjusted until its center is in line with the microscope tube. Turn on the light source of the tester, and place the radius bar on its upright support, shifting it until the image from the microscope objective is central and sharp on the bar's flat end. The bar should also be parallel to the bench tracks.

Next, the lens assembly is carefully slid along its parallel ways until the center of the lens under test just touches the end of the radius bar. The microscope assembly will now be very close to its final position, if an accurate template

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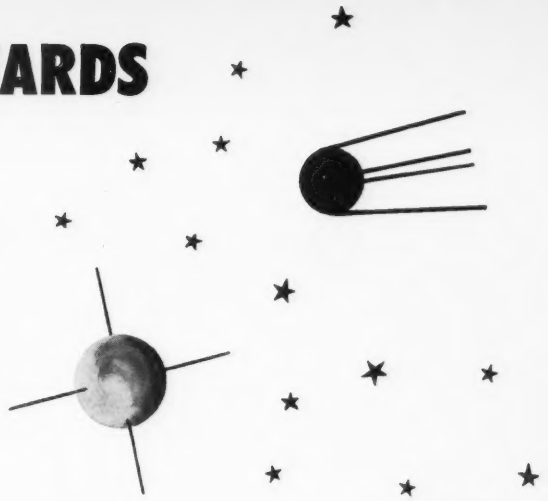

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For a hint at the generous dimensions of the UNITRON 6" — see the back cover.

SPECIFICATIONS

MAIN TELESCOPE — Objective: 160-mm. diam., 155-mm. (6") clear aperture; 2,500-mm. f.l.; resolving power, 0.74 sec.; in adjustable cell; coated. Eyepieces: 10 coated oculars for 42x to 625x, f.l. of 4, 5, 6, 7, 9, 12.5, 18, 25, 40, and 60 mm. Super rack-and-pinion focusing with locking mechanism and focusing scale.

VIEW FINDER — Objective: 62-mm. (2.4") diam.; 500-mm. f.l.; coated. Eyepiece: 12.5x (40 mm.) with crosshair. Standard rack-and-pinion focusing mechanism.

GUIDE TELESCOPE — Objective: 105-mm. (4") diam.; 1,500-mm. f.l.; coated. Eyepiece: 167x (9 mm.) with illuminated crosshair mechanism. De luxe rack-and-pinion focusing with locking mechanism and focusing scale.

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MOUNTING — Equatorial mounting, as described, with metal pier; choice of weight-driven or synchronous-electric-motor clock drive.

ACCESSORIES — Super UNIHEX Rotary Eyepiece Selector; star diagonal; Herschel solar diagonal; sun projection screen; sunglass; solar aperture diaphragm; UNI-BALANCE Tube Assembly.

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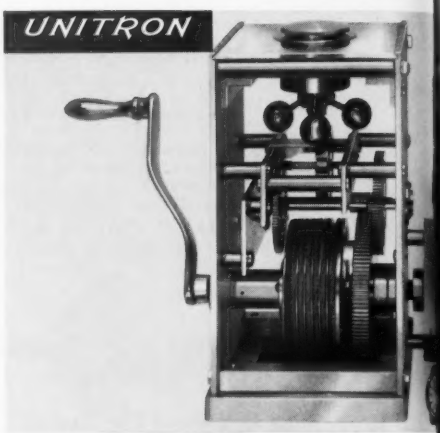
A CONTRAST IN TIMEPIECES

UNITRON's weight-driven clock drive for the 6" model is a larger version of the design that has proved so successful on the UNITRON 4" models. The manner in which it dwarfs the wrist watch in the picture at the right gives an inkling of its generous dimensions — more so, perhaps, than a mere statement that its main housing measures 6" x 6" x 11". A constant speed is maintained by the spinning governor, and a variable speed control provides the required rate for following stars, planets, or the moon. A synchronous-electric-motor drive may be selected instead of a weight-driven one.



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MODELS 80 AND 100

The UNITRON Astrographic Cameras feature a highly corrected objective, especially designed to meet the exacting requirements of astronomical photography. Because of their fast speed and wide field of view, they are ideal for the photography of star fields, constellations, nebulae, clusters, comets, and variable stars. The cameras come with large dewcap, dustcap, mounting brackets, ground-glass focusing screen, three double 3¼" x 4¼" plateholders, and fitted cabinet.

MODEL 80 — Three-element, Taylor-type, coated astrographic objective (at right in picture; standard accessory in Model 620):
80-mm. clear aperture; focal length 400 mm.; f/5. **$415**

MODEL 100 — Four-element, Tessar-type, coated astrographic objective (at left in picture):
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PRICE LIST

MODEL 600: UNITRON 6" Equatorial Refractor. Unit as described in the specifications on preceding page (but **without** cameras, 4" guide telescope, illuminated diagonal, and UNIBALANCE). Price **$5,125**

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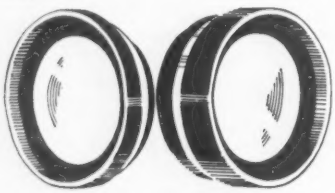

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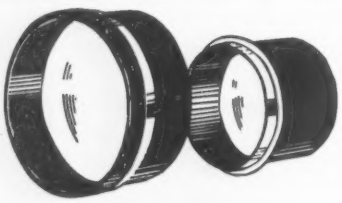

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North Hollywood, Calif.

was used and the surface fitted it closely.

It is now necessary to find the image from the microscope objective as returned by the concave surface. Begin by fastening a pocket flashlight along the top of the tube of the microscope assembly, making sure that the bulb end of the light is even with the end of the radius bar. Remove the radius bar and hold a piece of white paper below the microscope objective; with luck the image of the flashlight bulb returned by the surface will be found on the paper. Generally, however, this will not be the case, and the operator should stand with his eye about 6" behind the eypiece, moving his head until the flashlight's image is located. Using the azimuth and vertical motions of the lens holder, bring the image slightly below the microscope tube and then laterally until it is obscured by the support of the testing unit. The image should now be visible on the piece of paper held beneath the tube. Finally, bring the image as far below the tube as the flashlight is above it. We are next ready to find the image that comes through the objective, an operation best carried out in a darkened room.

Cut a smooth hole about ½" in diameter in the center of a piece of translucent white paper about 3" square. Holding this paper in front of the objective, move it along the optical axis until the image formed by the objective is sharp and close to the edge of the hole. Then move the paper perpendicular to the optical axis until the image just found falls inside the hole. On close inspection, the image being returned by the concave test surface should now be seen on the paper.

If it is not visible, there are two possible explanations. First, the returned image may fall entirely inside the hole in the paper, or it may even coincide with the source. Look in the eyepiece. If the image is not visible, hold the paper so that the image formed by the microscope stays at the edge of the hole and rotate the paper in a ½" circle, watching for a small spot of light. Probably it will not be found.

In that case, the second explanation holds for the loss of the returning image — it is not at the center of curvature and is too far out of focus to be seen. On a first trial, this is very often the case. To locate the reflection, keep the image formed by the objective centered in the ½" hole, and shift the paper toward and away from the objective until a sharp returning point of light is located.

In our example, suppose the image is located behind the focus of the objective, and slightly too high. By finding the two images alternately, it will be possible to estimate the distance between them along the optical axis. Move the microscope tube along its tracks by half this distance, and again check the sharpness of the images. They should now be quite close together, if the operator has been careful. Place the microscope-formed image just inside and at the top of the ½" hole in the paper and, by turning the screw that controls the vertical adjustment of the mirror, bring the two images into coincidence.

There should be visible in the eyepiece a circle of light, the out-of-focus image of the source returned by the concave test surface. Using the fine-thread screw, move the microscope unit to and from the lens until a sharp image of the reticle is seen. The reticle's image formed by the microscope objective is then exactly at the center of curvature of the surface under test. Take a first reading on the indicator or scale of the tester.

Now the support for the radius bar is placed in position, being carefully inserted between the lens and the objective. Take care not to damage the optical surface when moving the bar into place. The rounded end should first clear the surface, then be pushed cautiously against it with a small splinter of wood or a pencil point. Raise or lower the supporting stand, and move the bar laterally until the image of the source from the objective appears to be exactly centered on the small flat end of the bar. Again check that the rounded end is touching the test surface.

Look in the eyepiece and once more an out-of-focus image should be seen. In the example described, if the microscope is moved toward the rod, the image of the reticle will come into focus upon the end of the radius bar. It should be made concentric with the scratches from the crocus paper. *The difference between the readings from the test surface and from the radius bar is the error in radius of the surface.*

In our example, the indicator reading for the bar will be less than for the surface, revealing that the radius of the latter is too long. For a final check, carefully remove the radius bar and refocus the lens image, to verify that its position reading is unchanged. This insures that the system was not disturbed when the bar was inserted.

The quality of the image from the concave surface provides a check on sphericity. The poorer the sphere, the less sharp the image, and the greater the difficulty in focusing it.

During the fabrication of the Maksutov correcting lens, the test rig is used after each fine-grinding session. If the radius of the mirror is in agreement with the design value, no shifting of the microscope unit will be necessary when the bar is inserted in the tester.

While this test may seem complicated at first, it is fairly rapid after it has become more familiar. If amateurs in a group are making Maksutov lenses together, they should construct an accurate cell to support the test element, facilitating routine use of the equipment.

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CELESTIAL CALENDAR

Universal time is used unless otherwise noted.

MOON PHASES AND DISTANCE

Full moon	April	4,	3:45
Last quarter	April	10,	23:50
New moon	April	19,	3:23
First quarter	April	26,	21:36
Full moon	May	3,	12:23

	April	Distance	Diameter
Perigee	3, 21^h	221,800 mi.	33′ 28″
Apogee	16, 23^h	252,500 mi.	29′ 24″
	May		
Perigee	2, 6^h	223,400 mi.	33′ 14″

MINIMA OF ALGOL

April 3, 9:31; 6, 6:20; 9, 3:09; 11, 23:58; 14, 20:47; 17, 17:36; 20, 14:26; 23, 11:15; 26, 8:04; 29, 4:53. May 2, 1:42; 4, 22:31; 7, 19:20; 10, 16:09.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

April 5-6 **Alpha Librae** 2.9, 14:48.6 −15-52.1, 17. Im: **A** 3:02.4 +0.2 −1.6 165; **B** 2:59.2 −0.1 −0.7 154. Em: **A** 3:38.9 −1.9 +2.7 234; **B** 3:44.3 −1.5 +2.0 244; **D** 3:29.7 −1.9 +3.8 225.

April 22-23 **104 Tauri** 5.0, 5:05.0 +18-35.4, 4. Im: **H** 3:55.1 −0.5 −1.2 91; **I** 3:41.0 −0.9 −0.5 56.

The 5.3-magnitude star 8 Librae is only 3′.9 northwest of Alpha Librae, and from some parts of the eastern United States will also be occulted on the evening of April 5th. At station **A** it will reappear three minutes before Alpha Librae.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

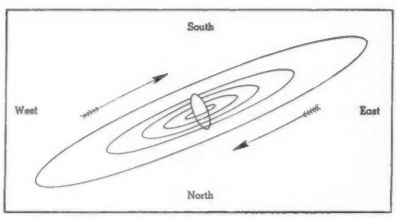
The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
		I +123°.1,	+49°.5		

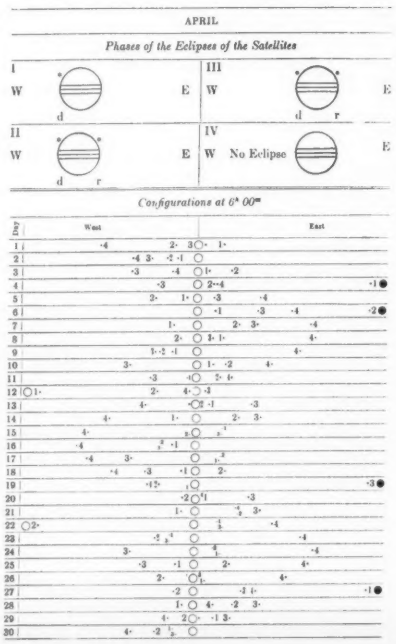
JUPITER'S SATELLITES

The diagram below, from the *American Ephemeris and Nautical Almanac,* shows the apparent orbits of the five inner satellites of Jupiter at the time of the planet's opposition, April 17, 1958. For clarity, Jupiter and the orbits have been elongated in the direction of the planet's polar axis in a three-to-one ratio. The faint innermost satellite, V, is invisible in amateur telescopes; therefore, it is not shown on the chart of daily positions of Jupiter's bright moons.



The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac.*



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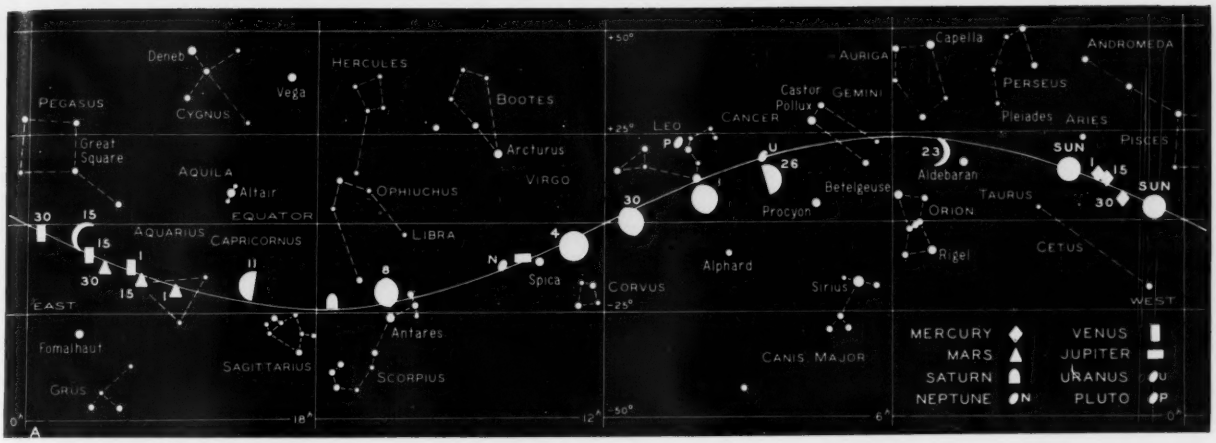

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

The sun will be eclipsed on April 19th, the path of the annular phase extending from the Indian Ocean across southeastern Asia into the North Pacific Ocean. Partial phases will be visible in Alaska, Japan, the East Indies, and Asia. Beginning times for the eclipse in Alaska are: Anchorage, 4:05 UT, Fairbanks, 4:06, and Nome, 4:00. At Honolulu, Hawaii, only the beginning of the event may be seen, at 4:20, for the sun sets before mid-eclipse.

The moon will undergo a very small partial eclipse next month, on May 3rd, with the beginning and end generally visible in the western part of the United States. The penumbral eclipse will begin at 10:10 UT, with umbral contact at 12:00 and mid-eclipse at 12:13, when the moon will be immersed only 0.015 of its diameter in the umbra. The moon will leave the umbra at 12:26, and the penumbra at 14:16.

Mercury is in the evening sky on April 1st, and sets about 1½ hours after the sun, its magnitude being +0.5. Mercury is well placed for observation the first few days of the month, but then moves rapidly toward the sun in the sky, reaching inferior conjunction on the 16th.

Venus comes to greatest western elongation on the 8th, 46° 23′ from the sun. Of magnitude −4.0 on this date, the planet rises nearly two hours before the sun and is a brilliant object low in the southeast before sunrise. Telescopically, the disk is 49-per-cent illuminated and 25″ in diameter.

Mars is a 1st-magnitude object in eastern Capricornus on April 15th, rising in the southeast about two hours before the sun. The ruddy planet is still so far away from us that its telescopic disk is only 6″ in diameter.

Jupiter reaches opposition to the sun on the 17th, 413 million miles from the earth, rising at sunset and visible all night. The planet is in eastern Virgo, appearing at magnitude −2.0, and has an equatorial diameter of 44″ and a polar diameter of 41″. The full moon will be close to Jupiter on the evening of April 4-5, conjunction occurring on the 5th at 3:39 UT, with Jupiter 1° 52′ north as seen from the center of the earth.

Saturn is near the border between Ophiuchus and Sagittarius in midmonth, rising a little before midnight, local time. Now magnitude +0.6, this planet is stationary in right ascension on the 4th, and then begins retrograde (westward) motion among the stars.

Uranus comes to eastern quadrature on April 28th; it is located in the western sky in the early evening. This 6th-magnitude object is in Cancer, about midway between Delta Cancri and Praesepe, and is well placed for binocular observations. On the 15th it is stationary in right ascension and begins direct motion, as shown by the chart on page 207 of the February issue.

Neptune is in opposition to the sun on the 24th, 2.7 billion miles from the earth. This 8th-magnitude planet is in retrograde motion in eastern Virgo; it crosses the meridian shortly after midnight, local time, and can be seen all night through small telescopes. See the February issue, page 207, for a finder chart.

Artificial satellite observing: Dusk or predawn observations of artificial satellites may be carried out with the aid of a star chart from a March or April issue for evening observations, from an August issue for morning.

W. H. G.

APRIL METEORS

The crescent moon will not interfere with observations of the Lyrid meteors, April 20-22. Maximum occurs on the 22nd, and about 12 meteors an hour may be seen by a single observer if good skies prevail. The radiant of the stream is located at right ascension 18h 12m, declination +34°.

W. H. G.

VARIABLE STAR MAXIMA

April 6, T Columbae, 051533, 7.6; 9, R Cancri, 081112, 6.8; 13, R Normae, 152849, 7.2; 22, U Orionis, 054920a, 6.6.

May 1, S Hydrae, 084803, 7.9; 9, R Aurigae, 050953, 7.8; 9, RV Sagittarii, 182133, 7.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

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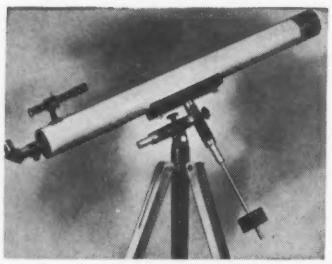

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OPTICS: The Satellite Scope has two important optical characteristics: A wide (51-mm.) diameter, low-reflection-coated objective lens. A six-element extremely wide-field, coated Erfle eyepiece that, in combination with the objective, gives 5.5 power with a big 12° field and over 7-mm. exit pupil.

OTHER USES FOR THE SATELLITE SCOPE

1. Makes a perfect wide-field finder. A special groove on the barrel helps in locating it in the finder mount. Fits our twin-ring finder mount, Stock No. 70,079-Y—$9.95. 2. Use the Erfle eyepiece on your regular astronomical telescope. You will need our adapter, Stock No. 30,171-Y—$3.95, which gives you an O.D. of 1¼". This eyepiece cost the government $56.00! 3. Makes a wonderful comet seeker; see complete asterisms. 4. Makes a fine rich-field telescope; see wide areas of sky with deep penetration.

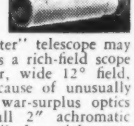
Especially Made for Members of MOONWATCH

Stock #70,074-Y.....$49.50 ppd.

Now — See the Satellites

NEW, LOW-PRICE "SATELLITER" TELESCOPE

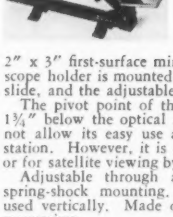
First Time — Only $9.95 ppd.



Get ready for the sky show as more satellites are vaulted into space. Our new, low-price "Satelliter" telescope may also be used to view comets and as a rich-field scope for viewing star clusters. 5 power, wide 12° field, slight distortion at outer edges because of unusually wide field. Use of high-quality war-surplus optics makes possible this bargain. Full 2" achromatic objective — large 9-mm. exit pupil for night use. Scope is 10" long, weighs less than one pound.

Stock #70,150-Y.....$9.95 ppd.

WAR-SURPLUS "SATELLITER" MOUNT



We have just discovered a radar tube mount (Gov't. cost about $50.00) that is very much like our mount for the regular MOONWATCH telescope. We include a spacer so that our $9.95 "Satelliter" telescope will fit the tube. You can attach a mirror on the end or purchase the model to which we have attached a 2" x 3" first-surface mirror with a metal bracket. The scope holder is mounted on a removable 4"-long T-slot slide, and the adjustable base has one 12" long.

The pivot point of the mirror holder will be about 1¾" below the optical axis of the mirror. This does not allow its easy use at an official MOONWATCH station. However, it is a minor point for other groups or for satellite viewing by an individual.

Adjustable through about 75° angle. Tube has spring-shock mounting. Also can be mounted and used vertically. Made of light-weight aluminum and magnesium.

Stock #70,151-Y....Mount only.....$6.00 ppd.
Stock #70,152-Y....Mount with mirror and bracket (as illustrated).....$9.00 ppd.
Stock #70,153-Y....Complete with mirror and $9.95 "Satelliter" telescope.....$18.95 ppd.

EDMUND SCIENTIFIC CO.

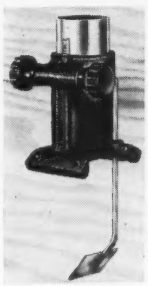
BUILD A SOLAR-ENERGY FURNACE

Great Project for Geophysical Year!

A fascinating new field. You can build your own solar furnace for experimentation — many practical uses. It's easy, inexpensive — use your scrap wood. We furnish instruction booklet. This sun-powered furnace will generate terrific heat — 2000° to 3000°. Fuses enamel to metal. Produces many unusual fusing effects. Sets paper aflame in seconds. Use our Fresnel lens — 14¼" diameter, f.l. 14".

Stock #70,130-Y....Package of 1.....$6.00 ppd.
Stock #70,131-Y....Package of 2.....11.00 ppd.
Stock #70,132-Y....Package of 4.....20.00 ppd.

Rack & Pinion Eyepiece Mounts



For Reflectors

For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,105-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

7X FINDER TELESCOPE—ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95
Stock #50,075-Y Ring mounts per pair.....$3.95

HUYGENS EYEPIECES

Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys!

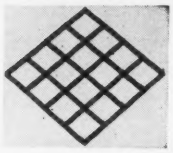
HUYGENS TYPE — STANDARD 1¼" DIAMETER
6-mm. (¼") Focal Length
Stock #30,063-Y.....$8.50 ppd.

12.5-mm. (½") Focal Length
Stock #30,064-Y.....$8.00 ppd.

COMBINATION EYEPIECE — 10-mm. and 20-mm.
Stock #30,065-Y.....$9.00 ppd.

RUBBER PITCH-LAP MAT

Saves Mirror Makers Time and Trouble

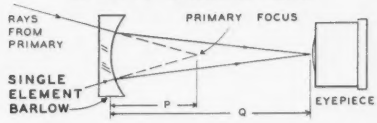


A rubber pitch-lap mat is used for forming the pitch-lap channels. Just pour the melted pitch on the tool, lay the mat on top and then press it in with your mirror to form the channels. When the pitch sets, an easy pull will remove the mat. In minutes instead of hours you are ready to polish. Eliminates time-consuming and tedious hand-cutting of the channels of the pitch lap.

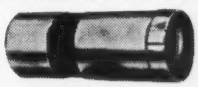
All those disappointing break outs of the pitch, common when hand-cutting the channels, are avoided. You no longer have to pour and cut two or three laps before getting a usable one. With our Rubber Pitch-Lap Mat you can use the first one you make.

Stock No.	Size	For Mirror Diam.	Price ppd.
50,171-Y	13½" x 13½"	8", 10", 12"	$2.00
60,061-Y	6" x 6"	4¼", 6"	1.00

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

OPTICAL IDEA & GADGET CONTESTS

In celebration of International Geophysical Year—

First Contest Ends April 30, 1958

Second Contest Ends Dec. 31, 1958

Our Catalog has full details on rules, prizes and entry blank — Write for Catalog "Y."

BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16", O.D. 1-5/16".
Stock #40,165-Y.....$1.75 ppd.

30-day Money Back Guarantee as with all our Merchandise!

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

SPITZ MOONSCOPE

A precision-made 32-power reflecting telescope — by makers of Spitz Jr. Planetarium. Clearly reveals the craters of the moon, shows moons of Jupiter, other wonders of the heavens. Based on same principles as world's giant telescopes. Stands 36" high on removable legs. Adjustable 3" polished and corrected mirror. Fork type altazimuth mount rotates on full 360° circle — swings to any location in the sky. Fascinating 18-page instruction book, sturdy carrying case.

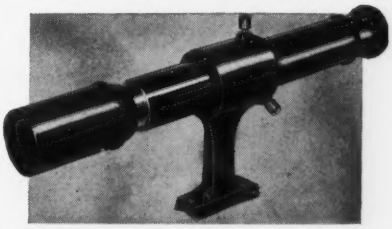
Stock #70,068-Y.....$14.95 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm. diam. objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

MISCELLANEOUS ITEMS

KELLNER EYEPIECE — 2" focal length (1¼" O.D.). Mount of black anodized aluminum.
Stock #30,189-Y.....$6.00 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18-mm. x 30-mm. — flat to ½ wave length.
Stock #30,143-Y.....$8.25 ppd.

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	6⅞"	7⅜"	60"		4.00
85,011-Y	2⅞"	3"	48"		6.00
85,012-Y	3⅞"	4"	60"	Aluminum	8.75
85,013-Y	4⅞"	5"	48"		9.00
85,014-Y	6⅞"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

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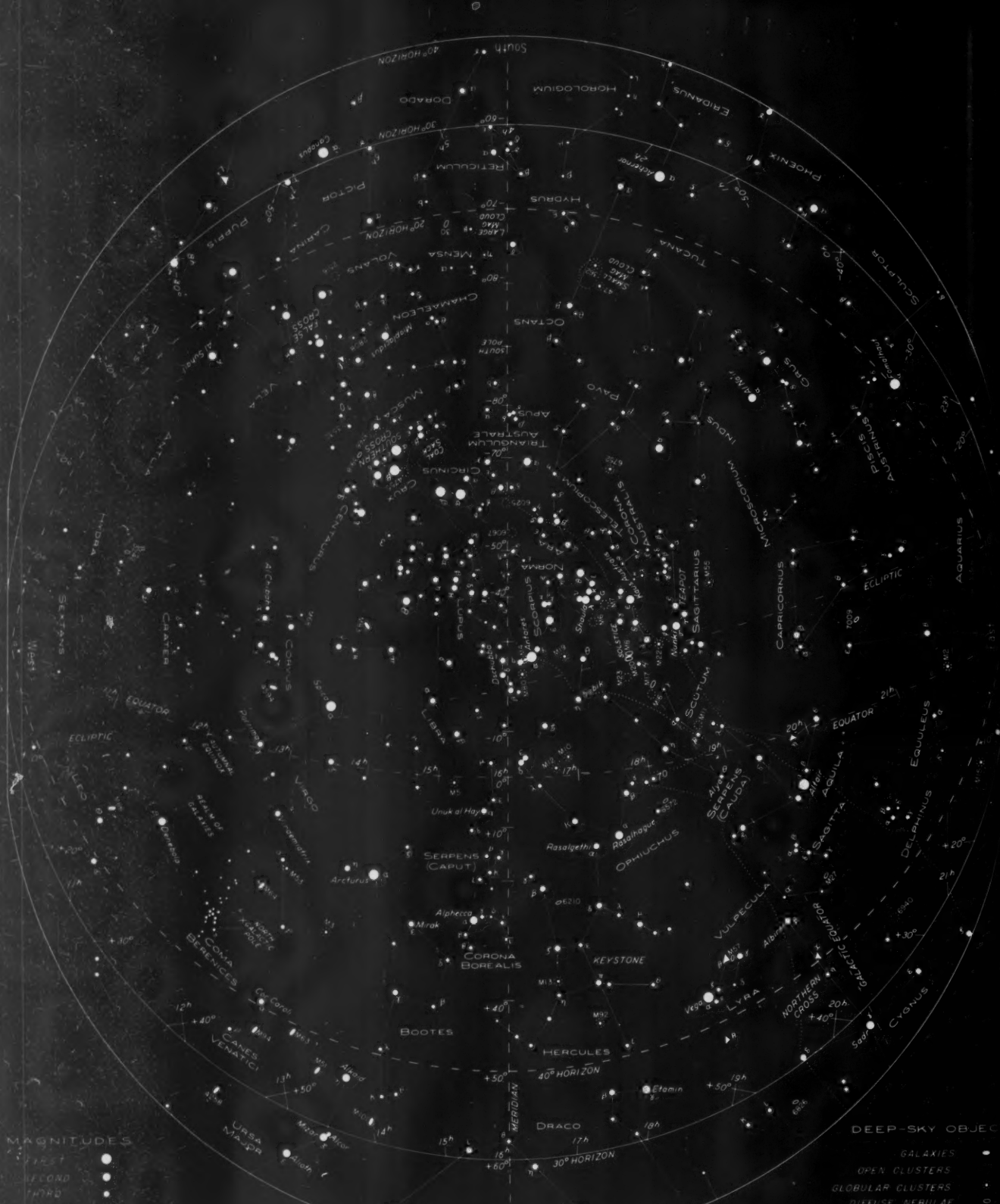
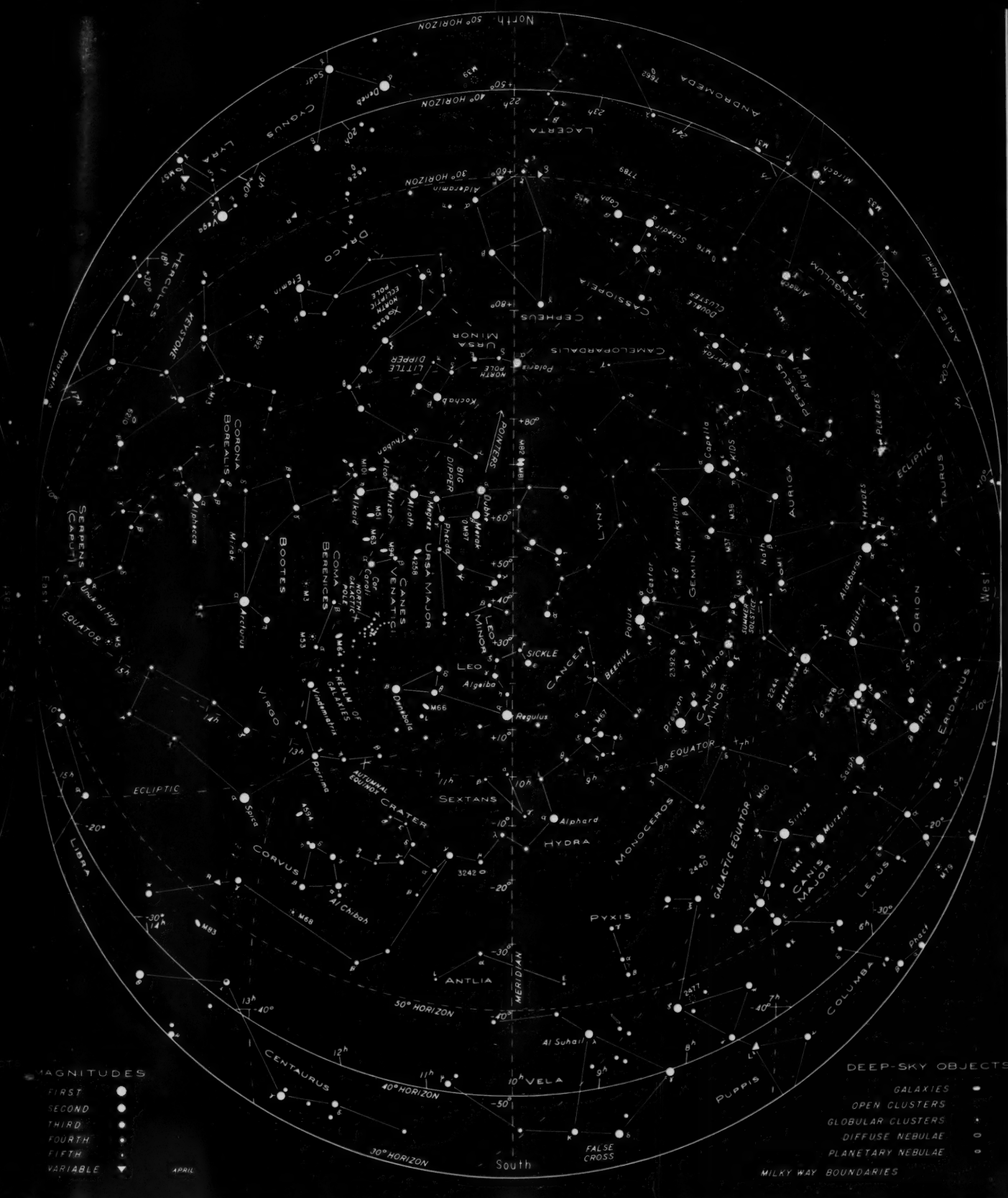


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of June, respectively; also, at 9 p.m. and 8 p.m. on July 7th and 23rd. For other dates, add or subtract ½ hour per week.

The little circlet of stars making the Northern Crown, Corona Borealis, is near the meridian partway up the northern sky. To its right (eastward) are the sprawling stars of Hercules, which is entirely above the horizon even for an observer at 40° south latitude.



STARS FOR APRIL

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of April, respectively; also, at 7 p.m. on May 7th. For other dates, add or subtract ½ hour per week.

Regulus is on the meridian at chart time, while to the west of it the Beehive cluster in Cancer can be seen as a faint fuzzy patch. Crater the Cup and Corvus the Crow are in the southeastern sky, and the inconspicuous constellation Antlia is low in the south.

CONGRATULATIONS U. S. ARMY!

Special Introductory Offer!

Radio Shack SATELLITE TELESCOPE

Official design — Built by Radio Shack to Smithsonian Project MOONWATCH specifications for optical tracking!

New! Exclusive at Radio Shack Corp. Special Introductory Price!

IDEAL AND EXACTING SPECIFICATIONS!

Type: refracting telescope normally used in seated position with view directed from front-surface mirror to eye at 90° angle. *Optics:* 7-power, 10° wide field, wide-field eyepiece (over 7-mm. exit pupil) with rubber guard. 51-mm. coated objective, long-throw focusing. *Mounting:* non-reflecting hardwood base, calibrated metal guide, one-knob control for rotating scope on axis. Front-surface mirror has hinged metal cover. Scope overall 2-9/16″ dia. x 13¼″ long.

Order No. SK-6104, Shipping wt. 4 lbs. $32.95

$32.95

Astronomy Clubs, Schools, MOONWATCH Teams Write for Quantity Discount Prices!

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☐ 1958 Satellite Telescope (SK-6104) at $32.95
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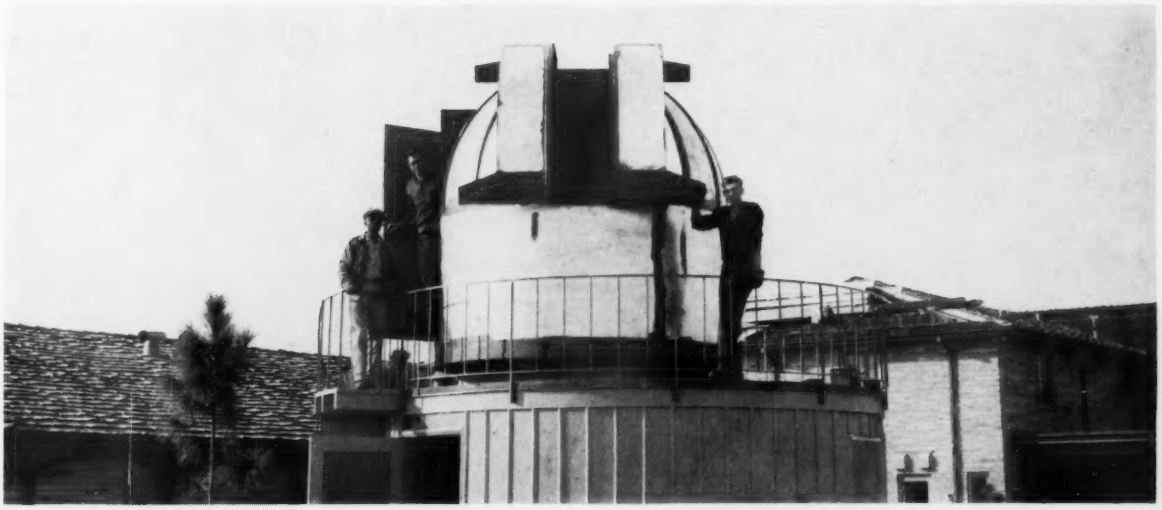

ASTRO-DOME, expert in the construction of observatory domes, has erected this 10-foot dome for an observatory at a home in Houston, Texas. The 8,000-pound dome is motor driven, rotating in a complete 360-degree circle, and has a full-sized entrance door. The double transverse shutters have special snow guards — a new feature of all Astro-Domes, for we now have special equipment permitting us to fabricate the intricate shapes required. Astro-Domes come in sizes up to 72 feet in diameter, and can be designed to your specific needs. May we assist you with your installation?

TINSLEY LABORATORIES, expert in the production of precision instruments, has custom built this 24-inch Newtonian-Cassegrainian reflector for a private observatory in Odessa, Texas. It features a 4-inch telescope for photographic guiding. A 10-inch refractor owned by the customer is mounted parallel to the 24-inch reflector for auxiliary use. The reflector has a rugged skeleton tube formed of a boxed center section and tubular struts. Its massive mounting is of the cross-axis type, on two piers, permitting continuous observing through the meridian. Driving motors, gear trains, the right-ascension worm, and 36-inch ring gear are all enclosed in dust-free housings. In every way, this instrument is of the highest professional quality, suitable for observations in a number of important astronomical programs. Tinsley engineering insures its trouble-free operation for a lifetime.

As experts in domes and telescopes, Astro-Dome and Tinsley Laboratories now make possible a complete observatory from telescope to housing at a cost that will be pleasantly reasonable. Write either company for details, which will be furnished without obligation.

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The New 6" brings to a highly successful conclusion years of painstaking planning, development and testing. Our object was not the production of just another large telescope, but one that would uphold and extend, in every way, the well-known UNITRON tradition and reputation. Optical excellence coupled with advanced design, unique features, matching accessories; the versatility of a custom built telescope at a much more attractive price. These were our goals, and those who have seen and inspected this superb instrument confirm that we have more than achieved them.

Astronomers have eagerly and patiently awaited details on the New 6" Refractor. Pages 312 and 313 carry full specifications and prices of the three models offered. You will, we know, fully agree that this is truly THE UNITRON OF UNITRONS.

Don't miss pages 312 and 313

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